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19 February 1982

USSR Report

METEOROLOGY AND HYDROLOGY

No. 12, December 1981

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Translations or abstracts of all articles of the Russian-language monthly journal METEOROLOGIYA I GIDROLOGIYA published in Moscow by Gidrometeoizdat.

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*Denotes items which have been abstracted.

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AIR SURFACE TEMPERATURE FORECASTING FOR 48 AND 60 HOURS IN ADVANCE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 22 May 81) pp 5-13

[Article by A. I. Snitkovskiy, candidate of geographical sciences, USSR Hydrometeorological Scientific Research Center]

[Abstract] A method is proposed for predicting minimum temperature for 48 hours in advance and maximum temperature for 60 hours in advance. In formulating prognostic expressions it appeared natural to use the concept of model output statistics, whose use made it possible to obtain positive results in predicting temperature for the first day. The MOS concept was used in developing an archives of data for predicting temperature for 48 and 60 hours. The initial data selected were for 1976-1980 -- 226 cases of minimum and maximum temperatures separately for each of the four seasons. The breakdown of the archives into four parts made it possible to take into account the characteristics of seasons of the year. The author arrived at a list of the potential predictors for solving this problem. It was found that the easiest season for prediction was autumn and winter the most difficult. Beginning in March 1980 the derived regression equations were used daily in preparing temperature forecasts for 48 and 60 hours. Checking of the temperature forecasts up to December 1980 indicated that the prediction of minimum temperature by these equations is better than a synoptic forecast but the prediction of maximum temperatures using the derived regression equations was somewhat poorer than a synoptic forecast. Accordingly, the procedure was corrected in order to rectify this situation. Now the prediction of minimum temperature for 48 hours is approximately 20% better than a synoptic forecast and the prediction of maximum temperature for 60 hours is better than a synoptic forecast on the average is 5-10%. An example of the forecast is given. Tables 5; references: 2 Russian.

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CORRELATION BETWEEN TEMPORAL AND SPATIAL INTERVALS IN NUMERICAL WEATHER PREDICTION

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 3 Apr 81) pp 14-24

[Article by V. M. Kadyshnikov, candidate of physical and mathematical sciences, and V. M. Ryazantseva, USSR Hydrometeorological Scientific Research Center]

[Abstract] The basis of numerical methods for short-range weather prediction is the approximate integration of the equations of a hydrostatic atmosphere. When using explicit finite-difference integration schemes the ratio of the temporal and spatial intervals must be related to the velocity of propagation of the front of wave disturbances by the Courant criterion, otherwise linear instability arises. In order to find this velocity it is necessary to examine a corresponding linearized system of equations, determine the energy interval for it and for wave solutions obtain the ratio of the energy flux to its density, that is, find the velocity of propagation of wave energy. The maximum of this parameter for all wave numbers will also be the sought-for wave front velocity. The authors illustrate this first in the example of the equations for a barotropic atmosphere. Then the horizontal velocity of propagation of the wave front in a baroclinic atmosphere is determined and finally, it is shown that the wave front is not propagated vertically in a hydrostatic atmosphere. Accordingly, the temporal interval in finite-difference models of a baroclinic atmosphere is dependent in explicit schemes only on the horizontal resolution. The velocity of wave front propagation in these models only slightly exceeds the corresponding value for a barotropic atmosphere, so that the interval can be the same as in barotropic models. The temporal interval is not dependent on the vertical resolution. This circumstance is well known in numerical forecasting, but its validation has evidently never before appeared in the literature. Figures 1; references: 9 Russian.

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GLOBAL TEMPERATURE TREND IN CENOZOIC

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 25-35

[Article by I. I. Borzenkova, candidate of geographical sciences, State Hydrological Institute]

[Abstract] This is a generalization of the results of determination of paleotemperatures by the oxygen isotopic method for the analysis of organogenic residues of marine plankton and benthos microfauna and also data from a paleobotanic analysis of fossil flora over the course of the Cenozoic (last 60-65 million years). The presented materials on the nature of change in parameters of mean water temperature and air temperature over the continents in different latitude zones lead to the following conclusions. 1. During the course of the last 60 million years at all latitudes in both hemispheres there has been a gradual decrease in temperature of the air and ocean (surface and deep layers), against whose background there were considerable variations in the direction of warming and cooling. 2. After the temperature maximum in the Early Eocene a gradual temperature decrease began, particularly strongly expressed in the high and middle latitudes. 3. Over the course of the Oligocene (38-22 million years ago) at all latitudes there was a predominance of a relatively cold climate with temperatures in the equatorial and tropical latitudes lower than at the present time. 4. The temperature increase beginning at all latitudes at the end of the Oligocene ended with the temperature maximum in the Early Miocene when the air and water temperatures in the equatorial latitudes attained values close to those of today. This period was the only period in the course of the entire Cenozoic when there was a considerable positive temperature trend. 5. The Early Miocene temperature maximum ended with a new temperature decrease in the high and middle latitudes which developed to the end of the Miocene and continued in the Pliocene. 6. The temperature regime of the equatorial and tropical latitudes in the course of the Miocene and Pliocene remained virtually unchanged; the temperatures in the Late Miocene attained values characteristic of the Late Eocene. 7. The temperature difference between the pole and equator changed during the course of the Cenozoic by a factor of almost 3 from values less than 10°C in the Early Eocene to 30°C in the Late Pliocene. Due to insignificant temperature variations in the low latitudes during the second half of the Cenozoic (Miocene-Pliocene) a change in the gradient occurred only due to a temperature decrease in the high and middle latitudes. 8. A sharp decrease in water and air temperature in the Middle and Late Miocene led to the formation of permanent glacier covers in the polar regions, first in the southern hemisphere and then in the

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Middle Pliocene also in the northern hemisphere. In this connection, over the course of more than 10 million years there was a clearly expressed asymmetry of the earth's climate when in the absence of glacier covers in the northern hemisphere the glaciation in the southern hemisphere already attained its present-day extent about 11 million years ago, that is, whereas the permanent glacier cover in the northern hemisphere appeared no sooner than 3 million years ago. 9. The northern hemisphere remained ice-free up to the beginning of the Pliocene, although individual traces of local mountain glaciations, such as in Alaska, date to 9-10 million years ago. The permanent glacier cover in Greenland began to form about 3.1-3.5 million years ago. The most ancient precipitation containing information on the presence of seasonal ice in the Arctic dates back some 4.5-5.0 million years ago. A permanent ice cover in the Arctic basin appeared only about 0.9-0.8 million years ago as a result of a marked decrease in global temperature. Figures 2; references 30: 6 Russian, 24 Western.

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FRICTION AND AIR HEAT EXCHANGE WITH SURFACE DURING TRANSPORT OF SAND, SALT AND ICE PARTICLES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 36-40

[Article by O. K. Zakharova, candidate of physical and mathematical sciences, State Hydrological Institute]

[Abstract] On the basis of solution of the equation for the dynamics of the surface air layer it is possible to compute the characteristics of sand particles in deserts. The saltation of particles with the diameter d occurs with satisfaction of the relationship

$$10^{-2} \leqslant v_*^2 \rho_{par}/\rho_{air} g d \leqslant 1,$$

where v_* is the dynamic velocity of the flow, ρ_{air} is the density of air, ρ_{par} and d are the density and diameter of the particles, g is the acceleration of free falling. The presence of saltating particles in the air changes the dynamic characteristics of the flow. The method is applicable for computing the transport of particles of an identical diameter and a stipulated density. This article gives the results of solution of the problem of air heat exchange with surfaces consisting of unconsolidated material. The examination is applied to deserts, the shores of dessicated lakes covered with salt and ice surfaces. The results were obtained on the basis of numerical solution of a system of equations for thermal conductivity and dynamics taking the presence of heat sources in the air into account. For saltating particles of sand, salt and ice with a diameter of $3\text{-}6 \cdot 10^{-4}$ m the author has obtained expressions for the coefficients of heat exchange and resistance for the level 2 m above the surface. These coefficients increase with wind velocity and are approximately twice as great in the case of moderate winds and three times greater during winds of hurricane force than in the case of absence of transport of particles by an air flow. Figures 2; references 5: 4 Russian, 1 Western.

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PREVAILING WIND AT ALTITUDES 80-100 KM AT DIFFERENT LONGITUDES DURING WINTER AND SPRING 1976-1977

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 41-45

[Article by N. A. Makarov, Institute of Experimental Meteorology]

[Abstract] A continuous cycle of observations was made from December 1976 through June 1977 at Khabarovsk (49°N, 135°E) in the Far East for the purpose of studying the wind regime at altitudes 80-100 km. A comparative analysis was made of the wind regime over Far Eastern and European regions using the results of long-term measurements at Obninsk (55°N, 38°E). The experimental data revealed that long-term series of the mean hourly wind velocity values in the meteor zone contain a broad spectrum of variations with periods from several hours to a year. For the purpose of discriminating changes in wind velocities with periods more than a day the time series of mean hourly values of the meridional and zonal components of wind velocity during the entire period of observations were subjected to harmonic analysis. The data indicated that zonal flows predominated over Khabarovsk at altitudes 80-100 km during most of the investigated period. In the behavior of the seasonal variation of the zonal component of the wind there are the same regularities which are revealed on the basis of long-term measurements at European middle-latitude stations, that is, westerly winds with velocities up to 20 m/sec during the winter season, restructuring to easterly at the beginning of spring, easterly winds in spring and at the end of spring to early summer, the setting-in of a summer regime of circulation with westerly winds. Accordingly, the results of measurements at Khabarovsk and Obninsk indicate that in general the seasonal variation of the prevailing wind at altitudes 80-100 km is similar over the Far Eastern and European regions. Figures 2, tables 1; references 9: 7 Russian, 2 Western.

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EFFECT OF RADIATION ON TURBULENT CLOUD MEDIUM

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 46-55

[Article by R. Kh. Almayev, candidate of physical and mathematical sciences, and L. P. Semenov, doctor of physical and mathematical sciences, Institute of Experimental Meteorology]

[Text]

Abstract: The authors investigated fluctuations in the intensity of transmitted laser radiation arising during the clearing of a turbulent cloud medium. In the approximation of geometrical optics and using the smooth perturbations method expressions are derived for the dispersion of fluctuations of the radiation intensity level. It is shown that the presence of fluctuations of the real and fictitious components of the dielectric constant of the cleared medium leads to the effect of a partial compensation of intensity fluctuations. The changes in the profiles of mean characteristics of the cleared cloud medium, associated with fluctuations of the radiation acting on the medium, are computed.

The problem of artificial modification of clouds and fogs by laser radiation for the purpose of creating extended zones of clearing, without the presence of droplets (for example, see [4] and the references therein), has been attracting great attention. Interest in this problem is dictated primarily by the fundamental possibility of the use of cleared zones for practical purposes. In [4], for example, there is a discussion of the possibility of using the clearing effect for improving visibility over airport landing strips and for increasing the effectiveness of operation of an optical signaling system in the presence of clouds and fogs.

As is well known, the principle for the clearing of cloud media by laser radiation is based on the evaporation of cloud droplets due to the absorption of the energy of radiation of definite wavelengths. In addition to the principal effect, an increase in medium transparency during interaction between radiation and the cloud, accompanying effects arise which are associated with the nonuniform heating of the air by evaporating droplets. In particular, during clearing of the turbulent cloud medium random nonuniformities of temperature, liquid water content and the dielectric constant are induced in addition to that existing prior to modification

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[1, 3, 5]. Depending on the modification conditions, the parameters of the medium and the radiation beam, the intensity of the induced fluctuations can vary in a wide range and considerably exceed the values observed in the undisturbed medium [1, 3, 5]. One of the most important mechanisms of the development of fluctuations of medium parameters is the mechanism of mixing of spatial inhomogeneities by the random wind field [1,5]. Specifics of formation of inhomogeneities of the dielectric constant ε in the cloud medium during the propagation of radiation is determined, first of all, by the fact that heating of the medium occurs by means of heat transfer from the heated droplets, and second, because of the peculiarities of evolution of the disperse fraction under the influence of radiation. The random field ε in the cloud medium to be cleared in turn is a source of scattering and attenuation of the transmitted radiation. The fluctuations of intensity of radiation arising in this case and their influence on the mean characteristics of the medium to be cleared are examined in this article.

Assume that the transmitted beam of laser radiation of the initial radius a_0 with the initial divergence $\vec{\theta}_0$ is propagated along the z-axis in an aerodisperse medium occupying the region $z \geqslant 0$ and carried by a wind with a fluctuating velocity and forms a cleared region in it which is characterized by a random field of the induced complex dielectric constant ε. We will assume that the influence of the droplets is limited to a nonuniform attenuation of the transmitted coherent part of the wave, whereas the radiation scattered by the droplets is completely carried beyond the limits of the beam. Such an assumption is correct for the optically narrow beams $2a_0\alpha_0 \ll 1$ considered here on paths with $\tau_0 \leqslant \tau_{lim}$ (α_0, τ_0 are the attenuation coefficient and the optical thickness of the undisturbed cloud medium). According to [7], in the atmosphere $\tau_{lim} \simeq 25$ for the densest clouds and $2a_0 \leqslant 1$ m. In this case the disperse medium can be considered quasicontinuous and it can be assumed that the induced fluctuations of ε in the modification zone are caused primarily by turbulent mixing. Since the dimensions of the inhomogeneities arising in the medium are $l \gg \lambda$, the propagation of radiation in the medium can be described by an equation for the complex phase of an electromagnetic wave Ψ in a parabolic approximation

$$2ik\frac{\partial \Psi}{\partial z} + \Delta_\perp \Psi + (\nabla_\perp \Psi)^2 + 2k^2\left(1 + \frac{\bar{\varepsilon}}{2} + \frac{\varepsilon'}{2}\right) = 0. \tag{1}$$

Here $\Psi = \ln E$, $E = Ae^{iS}$; A, $\underline{S}$ are the amplitude and phase of the electromagnetic wave; k is the wave number; $\bar{\varepsilon}$, ε' are the mean and fluctuation changes of the dielectric constant of the medium to be cleared, equal respectively to

$$\bar{\varepsilon} = \left(\frac{\partial \varepsilon}{\partial T}\right)_p (\bar{T} - T_0) + i\,\frac{\bar{\alpha}}{k}, \quad \varepsilon' = \left(\frac{\partial \varepsilon}{\partial T}\right)_p T' + i\,\frac{\alpha'}{k}, \tag{2}$$

where T, T', $\bar{\alpha}$, α' are the mean and fluctuation components of temperature and the attenuation coefficient of the medium, T_0 is the temperature of the undisturbed medium.

The spatial distribution of $\bar{\varepsilon}$ is described by the expression

$$\bar{\varepsilon} = \tilde{\varepsilon}_1 (1 - e^{-q}) + i\frac{\alpha_0}{k} e^{-q}, \tag{3}$$

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where

$$q = \frac{\beta_T \beta_p \alpha_0}{L W_0 V_0} \int_{-\rho}^{x} dx' I(x', y, z) \qquad \tilde{\varepsilon}_1 = \frac{(1-\beta_T) W_0 L}{\beta_T c_p} \left(\frac{\partial \varepsilon}{\partial T}\right)_p; \tag{4}$$

is a function of the thermal effect of the radiation; β_p, β_T are coefficients, averaged for the droplet spectrum, determining the fraction of radiation energy absorbed by a droplet from the beam and the fraction from the absorbed radiation energy expended on the evaporation of the droplet [4, 9]; W_0 is the liquid water content of the undisturbed medium; L is the specific heat of evaporation of water; c_p is the heat capacity of a unit volume of air; I is the intensity of radiation; V_0 is mean wind velocity, coinciding in direction with the x-axis.

It can be seen from (3) that ε rapidly tends to saturation with an increase in the thermal effect function. The latter occurs with movement of the observation point in the direction of an increase in the optical transparency of the medium to be cleared.

Here we will mention another peculiarity of the considered problem: the presence of fluctuations of the fictitious part of ε , which, as will be demonstrated hereafter, lead to the appearance of new effects. Making use of the smallness of fluctuations of the dielectric constant $\varepsilon' \ll 1$, we will seek the solution of (1) in the approximation of the smooth perturbations method. We will write the first two equations for this method:

$$2\, ik \frac{\partial \Psi_0}{\partial z} + \Delta_\perp \Psi_0 + (\nabla_\perp \Psi_0)^2 + 2\, k^2 \left(1 + \frac{\bar{\varepsilon}}{2}\right) = 0, \tag{5}$$

$$2\, ik \frac{\partial \Psi_1}{\partial z} + \Delta_\perp \Psi_1 + 2\, \nabla_\perp \Psi_0 \nabla_\perp \Psi_1 + k^2 \varepsilon' = 0. \tag{6}$$

Equation (5) is nonlinear, and not only due to presence of the term $(\nabla_\perp \Psi_0)^2$, but also as a result of the dependence of ε on A^2 caused by the effect of medium clearing. A solution of (5) was found in [8] in the approximation of geometrical optics. Such a solution is correct for paths with the extent $z \ll ka_0^2 = z_d$ (for example, for $a_0 = 20$ cm, $\lambda = 10.6\,\mu$m, $z_d = 25$ km). Assuming the solution of (5) to be known, henceforth we will concentrate our emphasis on solution of equation (6). We will assume that $\Psi_k = \chi_k + iS_k$, k = 0, 1, where χ is the amplitude level of the radiation, $\chi_0 = \ln A_0$, $\chi_1 = \ln A/A_0$. Since, as a rule, $a_0 \gg \ell_0$ (ℓ_0 is the minimum scale of the fluctuations of ε'), in (6) it is possible to omit the term $\nabla_\perp \Psi_1 \nabla_\perp \chi_0$, having the order of

$$\frac{\ell_0}{a_0} \Delta_\perp \Psi_1$$

and write an equation for Ψ_1 in the form

$$2\, ik \frac{\partial \Psi_1}{\partial z} + \Delta_\perp \Psi_1 + 2\, i \nabla_\perp S_0 \nabla_\perp \Psi_1 + k^2 \varepsilon' = 0. \tag{7}$$

The ε' value is found in [1]:

$$\varepsilon' = (-\varepsilon_1 + i\varepsilon_2) F_j V_j', \quad (j = x, y), \tag{8}$$

where

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$$\varepsilon_1 = \frac{\tilde{\varepsilon}_1}{V_0}, \quad \varepsilon_2 = \frac{a_0}{kV_0}, \quad F_j = q_j e^{-q}, \quad q_j' = \int_{-\infty}^{x} dx' \frac{\partial q}{\partial \rho_j},$$

ρ_j = (x', y). V' is the pulsation component of wind velocity.

We will neglect the nonlinear divergence of the beam of modifying radiation in comparison with the initial value: $\nabla_\perp S_0 \approx k\vec{\theta}_0$ [8]*. Assuming that the origin of coordinates is situated on the axis of the radiation beam, we select $\vec{\theta}_0$ in the form

$$\vec{\theta}_0 = \left\{ \frac{x}{F_x(1+f_x)}, \quad \frac{y}{F_y(1+f_y)} \right\}, \tag{9}$$

where F_j is the radius of curvature of the wave front along the j-axis at the entry into the medium; $f_j = z/F_j$. Taking (8) and (9) into account, from equation (7) we obtain the following expression for $\Psi_1(\vec{\rho}, z)$:

$$\Psi_1(\vec{\rho}, z) = \frac{k^2}{4\pi}(-\varepsilon_1 + i\varepsilon_2)\int_0^z \frac{dz'}{(z-z')} p_x^{1/2}(z', z)\, p_y^{1/2}(z', z) \times$$
$$\times \int d\vec{\rho}' F_j(\vec{\rho}', z')\, V_j(\vec{\rho}', z') \exp\left\{\frac{ik(\xi_l - \rho_l')^2}{2(z-z')} p_l(z', z)\right\}, \tag{10}$$

where

$$\vec{\xi} = (x p_x(z', z), \; y p_y(z', z)), \quad p_l(z', z) = \frac{1+f_l(z')}{1+f_l(z)}, \quad (l = x, y).$$

Here and in the text which follows the recurrent indices on the parameters F, V, ξ, ρ, p indicates summation. The clearing of cloud media in regular regimes of evaporation of droplets along adequately extended paths can be achieved only by use of broad beams of modifying radiation [10]. Accordingly, without substantial limitations it can be assumed that $z \ll ka_0^2$. Due to the rapidly oscillating exponent the principal contribution to the integral for $\vec{\rho}'$ in expression (10) is from the region $a_0 \gg |\vec{\rho}' - \vec{\xi}| \gtrsim \max(\sqrt{z/k}, \ell_0)$. Since the characteristic spatial scale of change of the function F_j is of the order of a_0, F_j can be considered a smooth function at the scales $\rho' \sim \sqrt{z/k}$, $\ell_0 \ll a_0$ and on this basis it can be removed from the integral for ρ'. Expressing the $V'_j(z, \vec{\rho})$ value through its Fourier transform $g_j(z, \vec{\varkappa})$ and integrating (10) for $\vec{\rho}'$ with allowance for what has been stated above, we obtain

$$\Psi_1(\vec{\rho}, z) = \frac{ik}{2}(-\varepsilon_1 + i\varepsilon_2)\int_0^z dz' F_j(\vec{\xi}, z') \int d^2\varkappa \times$$
$$\times e^{i\vec{\varkappa}\vec{\xi}} g_j(\vec{\varkappa}, z') \exp\left\{-\frac{i\varkappa_l^2(z-z')\, p_l(z, z')}{2k}\right\}, \quad (l = x, y). \tag{11}$$

Using (11) and assuming a local homogeneity and isotropicity of wind velocity fluctuations and their δ-correlation in the direction of the z-axis, we obtain an expression for the dispersion of fluctuations of the level of intensity of the modifying beam

$$\sigma_\chi^2(z, \vec{\rho}) = \pi k^2 \varepsilon_1^2 \,\mathrm{Re}\left\{\int_0^z dz' F_j(\vec{\xi}, z')\, F_k(\vec{\xi}, z') \int d^2\varkappa \times \right.$$
$$\left. \times \Phi_{jk}(z', \vec{\varkappa})\left[1 - \exp\left\{-\frac{i\varkappa_n^2(z-z')\, p_n(z', z)}{k}\right\}\right]\right\} + \pi k^2 \varepsilon_2^2 \times \tag{12}$$

---

* The condition for the indicated neglecting, obtained in a "stipulated field" approximation, has the form $\theta_0 > \frac{1}{2}\tilde{\varepsilon}_1 \frac{q_0(0)}{a_0 a_0}$.

$$\times \mathrm{Re}\left\{\int_0^z dz' F_j(\vec{\xi}, z') F_k(\vec{\xi}, z') \int d^2\varkappa \Phi_{jk}(z', \vec{\varkappa}) \times\right.$$

$$\times\left[1+\exp\left\{-\frac{i\varkappa_n^2(z-z')\,p_n(z', z)}{k}\right\}\right]\Big\} + 2\pi k^2 \varepsilon_1 \varepsilon_2 \int_0^z dz' F_j(\vec{\xi}, z') \times \qquad (12)$$

$$\times F_k(\vec{\xi}, z') \int d^2\varkappa \Phi_{jk}(z', \vec{\varkappa}) \sin\left[\frac{\varkappa_n^2(z-z')\,p_n^0(z', z)}{k}\right],$$

where $\Phi_{jk}(z', \vec{\chi})$ is the spectral tensor of wind velocity fluctuations; Re[B], Im[B] denotes separation of the real and fictitious parts of B,

$$\chi_l = 2\chi_1, \qquad j, k, n = x, y.$$

In the approximation of geometrical optics ($k \to \infty$) expression (12) coincides with the expression obtained in [2].

In (12) the first term, proportional to ε_1^2, determines the fluctuations of the level of intensity of radiation caused by scattering on temperature inhomogeneities ε'(Re ε'); the second term, proportional to ε_2^2, determines fluctuations of radiation caused by fluctuations of optical thickness (Im ε'). The third term describes fluctuations of radiation associated with cross-correlation of Re ε' and Im ε'. The presence of the second and third terms in (12) reflects the specific features of clearing of a cloud medium.

Fluctuations of the level of intensity of radiation in a medium to be cleared are nonhomogeneous and nonisotropic. This is indicated by the presence of the products $F_j(\vec{\xi}, z')F_k(\vec{\xi}, z')$ in (12). Thus, laser modification of a cloud medium, characterized initially by homogeneous and isotropic fluctuations of the parameters, leads to a qualitative change in its stochastic properties. We will note another peculiarity in behavior of fluctuations of the intensity level in the medium to be cleared. Formula (12) shows that the sign on the last term is dependent on the sign on $\varepsilon_1(\partial\varepsilon/\partial T_p$. For most gases $(\partial\varepsilon/\partial T)_p < 0$ and therefore in the considered case $\varepsilon_1 < 0$, and accordingly, the third term (12) is negative. The latter means that the presence of the cross-correlation Re ε' and Im ε' in a medium with $(\partial\varepsilon/\partial T) < 0$ leads to a decrease in the σ_χ^2 value in comparison with a case when Re ε' and Im ε' are not correlated. The degree of compensation is determined by the parameters of the beam and medium to be cleared.

A graphic interpretation of the cross-compensation effect can be obtained by examining a single event of interaction of radiation with an individual random inhomogeneity ε. Since

$$\mathrm{Re}\,\varepsilon' \sim -\left(\frac{\partial\varepsilon}{\partial T}\right)_p F_j V_j',$$

and Im $\varepsilon' \sim F_j V'_j$, in a medium with $(\partial\varepsilon/\partial T)_p < 0$ a random increase in the velocity of transport $V'_j > 0$ leads to a simultaneous increase in Re ε' and Im ε'. A local increase in Re ε' in turn causes a focusing of the radiation incident on the inhomogeneity ε', that is, increases the intensity of radiation due to the inhomogeneity. On the other hand, a synchronous increase in Im ε' is equivalent to an additional attenuation of the radiation, that is, exerts an effect inverse to Re ε'. With a decrease in the velocity of transport ($V'_j < 0$) a change in Re ε' leads to a

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decrease in the intensity of radiation and a change in Im ε' accordingly leads to its increase. In media with $(\partial\varepsilon/\partial T) > 0$ the indicated mechanisms are in phase and lead to an increase in fluctuations of χ_1.

We will compute σ_χ^2 for the spectrum of fluctuations of wind velocity in the form

$$\Phi_{jk}(\vec{\varkappa}) = C_V^2 \left(\delta_{jk} - \frac{\varkappa_j \varkappa_k}{\varkappa^2}\right) \varkappa^{-11/3} e^{-\varkappa^2/\varkappa_m^2} \qquad (13)$$

and the symmetric initial beam divergence $\theta_{0x} = \theta_{0y} = \theta_0 (p_x \equiv p_y \equiv p)$. In (13) $\varkappa_m = 5.92/\ell_0$, C_V^2, ℓ_0 are the structural characteristic and internal scale of wind velocity fluctuations respectively, δ_{jk} is the Kronecker symbol. Substituting (13) into (12) and making computations, we obtain

$$\begin{aligned}\sigma_\chi^2(z, \vec{\rho}) \simeq \frac{3\pi^2 k^2}{5} C_V^2 \varepsilon_1^2 \varkappa_m^{-5/3} \Gamma\left(\frac{1}{6}\right) \int_0^z dz' F_j^2(\vec{\xi}, z') \times \\ \times \mathrm{Re}\,[(1 + i\gamma)^{5/6} - 1] + \frac{6\pi^2 k^2}{5} C_V^2 \varepsilon_2^2 \varkappa_0^{-5/3} \int_0^z dz' F_j^2(\vec{\xi}, z') + \\ + \frac{6\pi^2 k^2}{5} C_V^2 \varepsilon_1 \varepsilon_2 \varkappa_m^{-5/3} \Gamma\left(\frac{1}{6}\right) \int_0^z dz' F_j^2(\vec{\xi}, z')\, \mathrm{Im}\,(1 + i\gamma)^{5/6} + \\ + 6\pi^2 k \varepsilon_1 \varepsilon_2 C_V^2 \varkappa_0^{1/3} \int_0^z dz' (z - z') p(z', z) F_j^2(\tilde{\xi}, z'),\end{aligned} \qquad (14)$$

where $\gamma = \dfrac{(z - z') p(z', z) \varkappa_m^2}{k}$;

$\Gamma(x)$ is a gamma function; $\varkappa_0 = 2\pi/\tilde{L}_0$; $\tilde{L}_0$ is the characteristic maximum scale of wind velocity fluctuations, determining the induced fluctuations Im ε'. A rigorous choice of the $\tilde{L}_0$ value is not possible. An evaluation of $\tilde{L}_0$ can be obtained taking into account the conditions of smallness of the relative wind velocity fluctuations in the atmosphere [6]:

$$\delta^2 = \overline{v'^2}/\overline{v_0^2} \lesssim 0.1.$$

Assuming $\overline{v'^2} \sim \tilde{L}_0^{2/3}$, $v_0^2 \sim L_0^{2/3}$ (L_0 is the external scale of turbulent pulsations V), we find $\tilde{L}_0 \lesssim \delta^3 L_0$.

We will examine two limiting situations: a) D 1 -- approximation of geometrical optics, b) $D = \varkappa_m^2 z/k \gg 1$ -- in this case diffraction on ε fluctuations is important.

a) Approximation of geometrical optics. Due to the inequality $D \ll 1$ we can write that $(1 + i\gamma)^{5/6} \approx 1 + 5/6\, i\gamma + 5/72\, \gamma^2 + \ldots$ and formula (14) is reduced to the following expression:

$$\begin{aligned}\sigma_\chi^2(z, \vec{\rho}) = \frac{\pi^2}{24} C_V^2 \varepsilon_1^2 \varkappa_m^{7/3} \Gamma\left(\frac{1}{6}\right) \int_0^z dz' (z - z')^2 \times \\ \times p^2(z', z) F_j^2(\vec{\xi}, z') + \frac{6\pi^2 k^2}{5} C_V^2 \varkappa_0^{-5/3} \varepsilon_2^2 \int_0^z dz' F_j^2(\vec{\xi}, z') +\end{aligned} \qquad (15)$$

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$$+\pi^2 C_V^2 \varepsilon_1 \varepsilon_2 k \varkappa_m^{1/3} \Gamma\left(\frac{1}{6}\right) \int_0^z dz' (z - z') F_j^2(\vec{\xi}, z') p(z', z). \tag{15}$$

The dependence of the first term in (15) on the internal scale of fluctuations ℓ_0 is similar to the dependence of σ_χ^2 on ℓ_0, obtained for the case of a "pure" turbulent atmosphere with an ε spectrum of the type (13) [6]. The dependence of the third correlation term on ℓ_0 is considerably weaker than the first. The value of the second term is determined by the scale L_0 of fluctuations of the dielectric constant since the greatest changes in radiation intensity are related to macroscale fluctuations of optical thickness.

We will compute the square of fluctuations of the intensity level in the clearing zone in the approximation of geometrical optics for paths with the extent $2\alpha_0^{-1} < z < F$. We will characterize the clearing zone in the cloud medium by the condition $q(z,\vec{\rho}) \simeq q_0(\vec{\rho}) - \alpha_0 z > 1$, where $q_0(\vec{\rho}) = q(z,\vec{\rho})|_{z=0}$ is the value of the thermal effect function at the cloud medium boundary. Integrating for z' in (15), we obtain

$$\sigma_\chi^2(z,\vec{\rho}) \simeq \frac{\pi^2}{16\alpha_0^3} C_V^2 \varepsilon_1^2 \varkappa_m^{7/3} \Gamma\left(\frac{7}{6}\right) e^{-2q}[q^2 + 3q + 3 + q_{0y}^2] + \tag{16}$$

$$+ \frac{3\pi^2 k^2}{5\alpha_0} C_V^2 \varkappa_0^{-5/3} \varepsilon_2^2 e^{-2q}\left[q^2 + q + \frac{1}{2} + q_{0y}^2\right] +$$

$$+ \frac{3\pi^2}{2\alpha_0^2} C_V^2 \varepsilon_1 \varepsilon_2 k \varkappa_m^{1/3} \Gamma\left(\frac{7}{6}\right) e^{-2q}\left[q^2 + 2q + \frac{3}{2} + q_{0y}^2\right],$$

where
$$q_{0y} \equiv \int_{-\infty}^{x} dx' \left.\frac{\partial q}{\partial y}\right|_{z=0}.$$

It can be seen from (16) that fluctuations in the intensity level decrease with an increase in the degree of clearing of the medium (q value). The minimum of the fluctuations in the clearing zone for radiation beams with an intensity decreasing from the center of the beam to the edge is attained in the plane y = 0, where the degree of clearing is maximum.

Now we will evaluate the effect of compensation of fluctuations of the radiation intensity level in the clearing zone. Comparing the first and third terms in (16), we find that

$$\frac{\{3\}}{\{1\}} \simeq \frac{24\beta_T}{(1-\beta_T)} \frac{c_p}{W_0 L} \frac{\alpha_0^2}{\left(\frac{\partial\varepsilon}{\partial T}\right)_p \varkappa_m^2} \sim 0{,}11 \frac{\beta_T}{(1-\beta_T)} \frac{(l_0 \alpha_0)^2}{W_0}, \ (W_0\ \text{г/см}^3). \tag{17}$$

It can be seen from (17) that the role of compensation of fluctuations increases with an increase in β_T, α_0 and the internal turbulence scale.

A comparison of the contributions of fluctuations of the real and fictitious parts of ε' to σ_χ^2 for typical values of cloud medium parameters indicates that in the geometrical optics approximation the contribution of Im ε' is usually small.

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b) Now we will examine the limit $D \gg 1$. In this case $(1 + i\gamma)^{5/6} \approx \gamma^{5/6} \times (\cos 5\pi/12 + i \sin 5\pi/12)$

and expression (14) for σ_χ^2 acquires the following form:

$$\sigma_\chi^2(z, \vec{\rho}) = \frac{3\pi^2}{5} k^{7/6} C_V^2 \varepsilon_1 \Gamma\left(\frac{1}{6}\right)\left[\varepsilon_1 \cos\frac{5\pi}{12} - 2\varepsilon_2 \times \right.$$
$$\left. \times \sin\frac{5\pi}{12}\right] \int_0^z dz' (z - z')^{5/6} p^{5/6}(z', z) F_j^2(z') + \frac{6\pi^2 k^2}{5} \times$$
$$\times C_V^2 \varepsilon_2^2 \varkappa_0^{-5/3} \int_0^z dz' F_j^2(\vec{\xi}, z') + 6\pi^2 k \varepsilon_1 \varepsilon_2 C_V^2 \varkappa_0^{1/3} \int_0^z \times \tag{18}$$
$$\times dz' (z - z') p(z', z) F_j^2(\vec{\xi}, z').$$

It follows from (18) that the second term, responsible for the χ fluctuations, caused by pulsations of optical thickness, coincides with the corresponding term in the approximation of geometrical optics (see (15)). The latter is associated with the fact that the principal contribution to this term is from macroscale inhomogeneities ε', diffraction on which for paths with an extent $k l_0^2 \ll z \ll k a_0^2$ is insignificant.

In the clearing zone for paths with the extent $2\alpha_0^{-1} < z < F$ formula (18) is reduced to the form

$$\sigma_\chi^2(z, \vec{\rho}) = \frac{\pi^2}{4 \cdot 2^{5/6} z_0^{11/6}} k^{7/6} C_V^2 \Gamma\left(\frac{5}{6}\right)\Gamma\left(\frac{1}{6}\right) e^{-2q}\left(\varepsilon_1 \cos\frac{5\pi}{12} - 2\varepsilon_2 \sin\frac{5\pi}{12}\right) \times$$
$$\times \left(q^2 + \frac{11}{6} q + \frac{187}{144} + q_{0y}^2\right) + \frac{3\pi^2 k^2}{5 z_0} C_V^2 \varkappa_0^{-5/3} \varepsilon_2^2 e^{-2q}\left(q^2 + q + \frac{1}{2} + q_{0y}^2\right) + \tag{19}$$
$$+ \frac{3\pi^2}{2 z_0^2} k \varepsilon_1 \varepsilon_2 C_V^2 \varkappa_0^{1/3} e^{-2q}\left(q^2 + 2q + \frac{3}{2} + q_{0y}^2\right).$$

Comparison of expressions (19) and (16) shows that the application of the results of geometrical optics to the region $z > k l_0^2$ leads to an exaggeration of the fluctuations caused by scattering on thermal inhomogeneities of ε by a factor of

$$\left(\frac{\varkappa_m^2}{z_0 k}\right)^{7/6}$$

It follows from (19) that there is a substantial increase in the role of fluctuations of the intensity level caused by pulsations of the optical thickness for extended paths: the contributions of fluctuations of the intensity level due to the real and fictitious parts of ε' on the paths $z \gg k l_0^2$ in the clearing zone can be comparable.

The σ_χ^2 distribution in the entire volume of the beam, including the transition zone, was computed numerically using formula (18) and is represented in Fig. 1. The figure shows that the nature of the distribution of the intensity fluctuations in the beam cross section is determined primarily by the relationship of $q_0(0)$ and $\alpha_0 z$. In the case of a poorly cleared medium (curve $q_0(0) = 1$), the radiation fluctuations in the beam cross section increase with movement from its windward edge

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(ξ = -1) to the leeward edge (ξ = 1). With $q_0(0) \geqslant 3$ there is a clearly expressed maximum of the intensity fluctuations which is displaced to the windward side of the beam with an increase in $q_0(0)$. In the clearing zone the intensity fluctuations decrease sharply with an increase in $q_0(0)$. We note that the nature of the behavior of σ^2_{ξ} in dependence on ξ, $q_0(0)$ is similar and agrees entirely with the behavior of ε fluctuations [1].

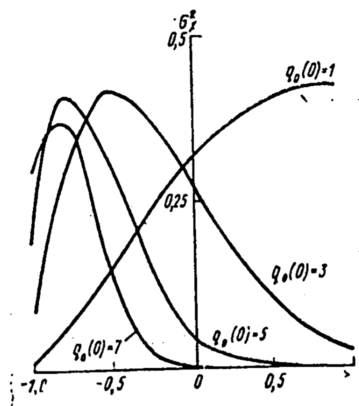

Fig. 1. Typical distribution of induced fluctuations of intensity level of modifying radiation along axis ξ = x/a in section y = 0, τ = 3 for different values of parameter $q_0(0)$ = 1, 3, 5, 7 and $\beta(\alpha_0 F)^{-1}$ = 0.05.

We will discuss the problem of change in the mean characteristics of the medium to be cleared (temperature, liquid-water content, transparency) caused by pulsations of the modifying radiation. In [3], where a study was made of the problem of clearing of the cloud medium by radiation with an intensity fluctuating at the entry into the cloud, it was demonstrated that the presence of intensity fluctuations of the modifying radiation should lead to a smoothing of the profiles of the mean characteristics of the medium in comparison with a case when the modification is accomplished by radiation with regular parameters. The intensity of the indicated effect is determined by the dispersion σ^2_q of fluctuations of the thermal effect function q. For the case considered here it can be assumed that

$$\sigma^2_q \simeq q_0^2(0) \frac{\rho_{\text{кор}}}{a_0} \int\limits_{-\infty}^{\xi} d\xi' \, j^2(\xi', y, z)\, \sigma^2_\chi(\xi', y, z), \tag{20}$$

[KOP = correlation]

where $j(\vec{r}) = \frac{\bar{I}(\vec{r})}{I_0(0)}$;

$\bar{I}(r)$ is the mean radiation intensity in the medium to be cleared; ρ_{cor} is the correlation radius of the χ fluctuations; σ^2_χ was stipulated by formula (18).

Numerical computations of change in the mean characteristics of the medium to be cleared due to the induced q fluctuations, stipulated by expression (20), carried out for a large set of cloud and radiation beam parameters, indicated that in the considered situation these changes are insignificant. As indicated by an analysis, the latter is attributable to the fact that the fluctuations of radiation

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intensity, determining σ_q^2, are small both in regions with a high degree of clearing, due to the smallness of the ε pulsations induced in the medium, and in regions with a low degree of clearing due to a considerable attenuation of radiation by nonevaporating cloud droplets.

We note in conclusion that the investigation of the induced χ fluctuations was carried out without allowance for the influence of gas absorption of radiation on the formation of ε fluctuations. Such an examination is correct for dense clouds and fogs when $\alpha_0 \gg \alpha_g$ (α_g is the coefficient of attenuation of radiation by the gas component of the atmosphere). As indicated by the analysis, gas absorption can change the distribution of ε fluctuations in the region

[Γ = g = gas]

$$q > \ln\left[\frac{\alpha_n(1-\beta_\Gamma)}{2\alpha_\Gamma}\right].$$

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FEATURES OF MASS EXCHANGE DURING COLLISION OF WATER DROPLETS OF NONCOMPARABLE SIZE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 56-60

[Article by A. V. Kolpakov and S. M. Kontush, candidate of physical and mathematical sciences, Odessa State University]

[Abstract] The article describes an experimental method and presents the results of experiments for investigating the phenomenon of partial coalescence of droplets at the time of collision of droplets of noncomparable sizes. The experiments were carried out with droplets with a radius $50 \leqslant r_1 \leqslant 150\,\mu$m which collided with target droplets with a radius $500 \leqslant R \leqslant 1500\,\mu$m with a change of velocity in the range $20 \leqslant v_1 \leqslant 200$ cm/sec. The experimental apparatus is described. The authors derived functional expressions relating the parameters of the droplets before and after collisions and the partial coalescence mechanism is explained. Expressions are also derived which determine the limits of existence of partial coalescence for a stipulated range of change of the collision parameters. All this not only makes it possible to take into account the existence of the partial coalescence phenomenon when designing different kinds of aerosol apparatus, but also to control actively the various processes changing the value of the input parameters. The results once again indicate the need for a separate examination of experimental studies on the value of the r_1/R parameter because when this parameter has substantially different values it is necessary to expect a prevalence of different processes. Figures 3; references 12: 8 Russian, 4 Western.

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COMPUTATION OF VERTICAL TURBULENT FLUXES IN NEAR-WATER ATMOSPHERIC LAYER OVER OCEAN IN TROPICAL LATITUDES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 31 Mar 81) pp 61-68

[Article by T. F. Masagutov, Institute of Experimental Meteorology]

[Abstract] It is generally recognized that the turbulent exchange of heat, momentum and moisture through the ocean-atmosphere interface plays a highly important role in the formation of weather over the earth. But at the present time there is no technical possibility for organizing measurements of these characteristics by a direct method on the necessary scale. Moreover, it is virtually impossible to organize measurements of fluxes of these substances, for example, in a zone occupied by a tropical cyclone. This accounts for the fact that during recent years an effort has been made to develop indirect methods for computing the fluxes of heat, momentum and moisture on the basis of data from standard meteorological observations. However, on the basis of direct experimental data it has recently been demonstrated that the presently widely used indirect methods for computing the fluxes of heat and momentum on the basis of data from mass hydrometeorological observations do not provide the accuracy required for practical purposes. This article outlines an improved method with application of the great volume of recently acquired experimental data, for example, data on the structure of turbulence in the near-water layer of the atmosphere obtained in "ATEX-69," "BOMEX-69," "ATEP-74" and on a number of other expeditions. The author has obtained an explicit form of the dependence of the energy exchange coefficients on the characteristics of the flux and sea surface roughness. These results are used in formulating a refined scheme for computing the fluxes of heat, moisture and momentum on the basis of data from standard meteorological observations. Figures 4; references 23: 12 Russian, 11 Western.

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UDC 551.463.6(215-17)

OBJECTIVE ANALYSIS OF OCEAN SURFACE TEMPERATURE IN NORTHERN HEMISPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, 1981 (manuscript received 14 Apr 81) pp 69-76

[Article by A. N. Bagrov, candidate of physical and mathematical sciences, and N. N. Kozhevnikova, USSR Hydrometeorological Scientific Research Center]

[Text]

Abstract: The article describes a scheme for the objective analysis of the temperature field of the ocean surface in the northern hemisphere by the optimum interpolation method. The analysis is made using data from shipboard observations accumulated during a five-day period. The data were subjected to climatic and horizontal checking. The scheme was applied using a BESM-6 electronic computer in FORTRAN algorithmic language. The results of the analysis are fed out for the points of intersection of a grid 2.5 x 2.5° covering the entire northern hemisphere (except for the territory of the land and polar regions). Recommendations are given for further improvement of the results.

Anomalies of the thermal state of the ocean surface exert a substantial influence on meteorological processes in the atmosphere. Objective analysis of ocean surface temperature is also intended for taking into account nonadiabatic factors in different prognostic models of the atmosphere. In addition, in the future it is desirable that the results of this analysis replace the manual analysis of ocean surface temperature now employed at the USSR Hydrometeorological Center, involving manual plotting of a great volume of data on the map.

In a study by V. A. Avdeyev [2] a scheme was proposed for objective analysis of water temperature for the North Atlantic. But it was oriented on an antiquated technology and never entered into operational practice. Our analytical scheme, as well as that described in [2], is based on the optimum interpolation method and in many respects conforms to the operational scheme given in [3] for analysis of surface meteorological fields (including the air temperature fields). The same as scheme [3], it is applied using FORTRAN language with a BESM-6 electronic computer.

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Initial data. As the initial data in the analysis use is made of synoptic telegrams (in the KN-09 code) from commercial and scientific research ships in which, in addition to other information, data on temperature of the ocean surface are given. The number of such summaries from the northern hemisphere arriving at the USSR Hydrometeorological Center at any main observation time (0000 or 1200 GMT) averages 650. The commercial ships from which the overwhelming number of shipboard telegrams arrives for the most part sail along standard routes. Thus, information for the northern hemisphere is distributed extremely nonuniformly: in addition to regions of vigorous marine shipping, from which even some excess of observational data is obtained, there are some extensive regions which are extremely poorly covered by data. As a rule these are the tropical regions of the Pacific and Atlantic Oceans. Since the temperature of the ocean surface is an extremely inert characteristic, and also due to the inadequate volume of data received for one observation time, in oceanological practice at the present time it is customary to "mix" these data for a five-day period, that is, plot all the information arriving during a five-day period. In actuality, in regions of vigorous shipping only some part of all the arriving summaries is plotted, whereas in poorly covered regions all the water temperature summaries are plotted.

Although data on water temperature of the ocean surface are transmitted with an accuracy to 0.1°C, the actual accuracy of these measurements is probably considerably lower and does not exceed ±1°C, but according to the considerations of some authors, ±1.5°C [8]. This occurs as a result of the primitive technique for the measurements themselves, mixing of the water surface layer due to ship movement, etc. In addition, the observations are not made by professional observers and therefore a rather high percentage of error is obtained. The plotting of this information on one map helps in averaging it somewhat and facilitates checking. In our work on the objective analysis of temperature of the ocean surface we also "mixed" data on water temperature for a five-day period, as this is now done in oceanological practice.

We made use of the already existing techniques of the operational data processing system organized for the purposes of numerical short-range forecasting on a BESM-6 electronic computer employed at the USSR Hydrometeorological Center. All the hydrometeorological data from the communication channels are fed to the magnetic tapes of a "Minsk-32" electronic computer. Then at the necessary moments in time ("cut-off times") through a special inter-machine communication channel it is transmitted to a BESM-6 electronic computer. The "cutoff time" for a regional operational forecast is 2.5 hours, but for a hemispherical forecast -- 5.5 hours from the moment of observation. During these times it is possible to receive about 75 and 95% of all the shipboard synoptic telegrams respectively relating to a particular observation time (it should be noted that the shipboard synoptic summaries lag considerably behind similar telegrams from land stations in the northern hemisphere). In the BESM-6 electronic computer the arriving information, including shipboard synoptic telegrams, is subjected to primary processing [5]. As a result, "hard" formats of shipboard telegrams are obtained, that is, such formats in which each meteorological element corresponds to a definite place. In this process repeated summaries are eliminated, there is some syntactical control of communications, etc. After computing the regional and hemispherical forecast the processed initial data for each observation time are accumulated through a data bank system (authors -- V. A. Antsypovich, V. R. Al'tshuler) in a special five-day cyclic archives (author of program -- A. Yu. Birkgan). We use information from this archives for computing an analysis of ocean surface temperature.

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In this analytical scheme an important role for checking and interpolation purposes is played by the climatic characteristics $\bar{t}$ and σ (norm and standard deviation) of the water temperature field. As the $\bar{t}$ fields we used the mean monthly characteristics at the points of intersection of a 5 x 5° grid from the American DST-6 archives, registered on magnetic tapes in the international format and available at the USSR Hydrometeorological Center. It was important that these fields are smoothly continued onto the territory of the land. A comparison of these fields with the climatic fields $\bar{t}$ available to us revealed their good correspondence. The monthly fields of the mean square variability were taken from magnetic tapes prepared at the Swedish Hydrometeorological Institute for the processing of data in FGGE level-II form [7]. These fields, in our opinion, correspond well to the geographical distribution of σ, although they are somewhat understated in absolute value. Special mathematical support for the readout of climatic data was created by A. M. Gofen and A. D. Naumov.

Preliminary checking. First all the data on ocean surface temperature are subjected to some preliminary checking. For this purpose the ship coordinates and water temperatures are selected from the formats of the shipboard synoptic telegrams. Ships in the southern hemisphere are excluded, as well as data for ships with incorrect coordinates, that is, ships whose coordinates erroneously fell on the land, not at sea. There is also a rough "climatic checking" of communications on water temperature on the basis of the degree of their deviations from the climatic values. Using the ship's coordinates from the 5° grid in which the climatic values are stipulated there is a bilinear interpolation of $\bar{t}$ and σ values for this ship. All the shipboard communications on water temperature t falling beyond the framework $\bar{t} \pm 4\sigma$ are considered erroneous. This type of checking henceforth can be made more effective if instead of climate one uses the results of an analysis of water temperature for the preceding five-day period. A subsequent more precise type of checking is already carried out within the framework of the optimum interpolation method.

Interpolation; horizontal checking. As the interpolation method we used the well-known optimum interpolation method based on use of the statistical characteristics of the fields to be analyzed. This method has won wide recognition and is finding increasingly wider use in the analysis and assimilation of different meteorological fields. It is assumed that the fields of deviation of a meteorological field from the norm are homogeneous and isotropic. For the water temperature field this assumption is more or less satisfied.

Then computations of the value of a meteorological element at a point of intersection of a regular grid (or at a ship being checked) are accomplished using the formula

$$t_0 = \bar{t}_0 + \sum_{i=1}^{4} p_i t'_i. \tag{1}$$

Here $\bar{t}_0$ is the climatic water temperature value at a grid point of intersection (at the ship to be checked); $t'_i = t_i - \bar{t}_i$ are the deviations of water temperature from climate at the influencing ships (we took only four influencing ships); p_i are the weights of the influencing ships, which are determined by solution of a system of linear equations

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$$\sum_{j=1}^{4} p_i \mu_{ij} + p_i \eta = \mu_{0i} \; (i = 1, 2, 3, 4), \tag{2}$$

where μ are the corresponding values of the normalized autocorrelation function; $\eta = 0.02$ is a term specially introduced into the matrix diagonal for better conditionality of the system of equations.

The problem of the autocorrelation function for ocean surface temperature has not yet been investigated adequately. Difficulties in determining the water temperature spatial correlation functions are related to the absence of a constant network of stations in the ocean which would ensure simultaneous observations of water temperature in different regions of the ocean, such as, for example, synoptic stations on the land. We know of results of an investigation of autocorrelation functions [1, 6] which are contradictory. The autocorrelation functions $\mu(r)$ obtained in [1], in our opinion, are improbable because the correlation coefficient remains extremely high for distances of even more than 2,000 km, which is probably attributable to failure to take the measurement errors into account. As $\mu(r)$ we took the power-law expression

$$\mu(r) = \left(1 + \frac{r}{L}\right) \exp\left(-\frac{r}{L}\right), \tag{3}$$

where r is the distance in thousands of kilometers, L = 0.35.

An autocorrelation function of the type (3) is used in an analysis of the surface meteorological fields [3] and is close to the air temperature autocorrelation function. Source [6] presented statistical investigations of the water temperature fields on the basis of expeditionary data and one of the autocorrelation functions obtained there is close to that which we adopted.

The checking of the communicated initial data on water temperature is accomplished by the horizontal checking method [4] by an interpolation of values from the four ships closest to the particular ship. As in any interpolation method it is important here that all the influencing ships insofar as possible uniformly surrounded the particular grid point of intersection (ship to be checked). Accordingly, in the scheme the search for influencing ships is carried out in such a way that not only the nearest influencing ships were selected, but also that insofar as possible they be situated in all four quadrants surrounding the particular point of intersection (ship to be checked). The discrepancy between the temperature communicated by the ship and the interpolated value Δt is compared with the theoretical interpolated error, increased by several times. The need for such an increase is attributable to the fact that in a number of cases there is an impairment in the condition which we adopted concerning the homogeneity and isotropicity of the fields of deviations from the norms. The possible interpolation error is computed using the formula

$$\sqrt{E} = N \sigma \sqrt{\varepsilon}, \tag{4}$$

where $\varepsilon = 1 - \sum_{t=1}^{4} p_i \mu_{0i}$ is the theoretical measure of the interpolation error; σ is the standard deviation of water temperature; N = 10 is an empirically selected factor.

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The $\mathcal{E}$ parameter is essentially dependent on the density of the network of ships and their relative locations and also on the autocorrelation function used. The N factor was selected in such a way that insofar as possible shipboard communications with incorrect data were rejected and correct communications were retained. If in the horizontal checking it appears that $|\Delta t| \leqslant \sqrt{E}$, the data for the ship to be checked are considered correct. However, if $|\Delta t| > \sqrt{E}$, there is an error in the initial data -- for the ship to be checked, or for some one of the influencing ships. For solving this problem use is also made of information from a fifth nearlying ship and interpolation is carried out for the ship to be checked with alternate exclusion of data for each of the four initially selected ships. If in all four cases $|\Delta t| > \sqrt{E}$ remains, it is obvious that the data for the ship to be checked are incorrect and they are rejected; otherwise it is assumed that the data for one of the surrounding ships are erroneous (which will be checked in turn). Detailed information on all types of checking is printed out.

Horizontal checking is ineffective in those rare cases when ships in a row communicate incorrect information with an error in one and the same direction. In these cases either a more preliminary checking (on the basis of deviation of the analysis for the preceding five-day period from the field), or, sometimes, the repeated carrying out of the horizontal checking procedure can be of assistance.

Search for influencing ships. In a rapid search for the influencing ships use is made of the so-called "machine map" method. For this purpose a square is constructed on a map of the northern hemisphere in a stereographic projection at a scale of 1:30 000 000. This square is described around the circumference of the equator, which is in turn broken down into 160 x 160 small squares with 5-mm sides on a blank map (150 km at latitude 60°). We require that in each such small square there will be no more than two influencing ships; preference is given to data for later times from the five-day period. The remaining information is considered excess and is discarded. This limitation is related to the electronic computer memory; it enables us to have a network of more uniformly spaced ships.

The octal numbers of one or two ships are entered in each such square; if not one ship falls in a square, it remains empty. Using this number it is easy and quick to find the Cartesian coordinates of the ship, data on temperature for the ship in the form of deviations from climate, conditional index, etc. present in the individual data masses. In the search for influencing data the first step is to determine the small square corresponding to the interpolation point (ship to be checked); then the search for the nearest nonempty squares begins. The search is carried out in a spiral with a gradual increase in radius to a maximum of 1500 km. In addition, the already mentioned symmetrization of search in four quadrants is introduced. If the ship is situated closer than 50 km from the interpolation point, the interpolation is not carried out and the point is assigned the water temperature value at this ship. If there is not a single ship within the radius of maximum search, the point is assigned the climatic value.

Results. Interpolation is carried out at the points of intersection of a grid measuring 2.5° x 2.5° for the region of the entire northern hemisphere with the exception of the land and polar regions (to the north of 70°N). As an example of the computations we give the results of an analysis of water temperature during the

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five-day period 11-15 June 1980. For technical reasons during this period we used information only for the two principal observation times -- 0000 and 1200 GMT; for 0000 hours the "cutoff time" was 2.5 hours, and for 1200 hours -- 5.5 hours. The volume of arriving data and the volume of data discarded as a result of different kinds of checking and the adopted search system are as follows:

Total shipboard telegrams received	6095
of which the number from the southern hemisphere is	492
ships with land coordinates	115
no data on water temperature	624
no climatic checking	234
did not enter into "machine map"	1632
enter into "machine map"	2998
did not undergo horizontal checking	105
useful communications	2893

90 70 50 30 10 10 30

0	0	0	0	0	0	0	0	3	82	28	100	13
0	0	0	0	0	0	0	0	3	16	12	17	9
0	0	0	0	1	6	13	3	7	191	21	0	20
0	0	0	0	1	3	6	3	7	29	12	0	11
0	0	1	11	8	29	15	19	31	100	27	9	0
0	0	1	7	7	20	9	18	19	35	14	3	0
0	5	37	51	89	36	58	55	113	27	2	8	16
0	4	31	41	51	35	48	41	42	16	2	5	13
2	54	50	49	46	39	24	65	55	50	49	50	2
2	42	49	45	44	38	24	57	34	23	28	32	2
49	58	56	38	28	22	8	73	0	0	0	0	18
43	53	54	37	26	21	8	33	0	0	0	0	14
10	43	43	14	11	2	20	83	0	0	0	0	6
10	42	38	14	11	2	20	43	0	0	0	0	4
24	4	0	4	6	2	12	34	5	2	0	0	0
23	4	0	4	6	2	12	24	5	2	0	0	0

90 70 50 30 10 10 30

Fig. 1. Information for the North Atlantic on the availability of information in "machine map." 11-15 June 1980.

In particular, we see that there are great losses of information due to the system for the search of influencing ships which we used. We note that for interpolation purposes it is best to have a dense and uniform observation grid. In actuality, a dense network of water temperature observations is available only along standard sea routes. In these regions there are even significant losses of information due to our search system.

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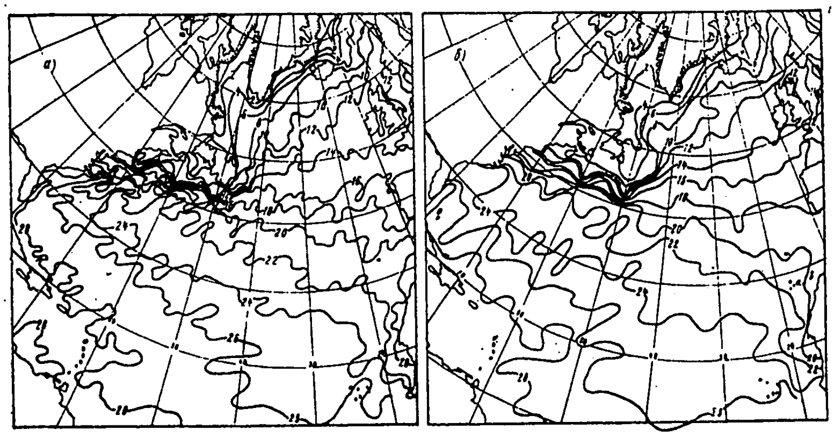

Fig. 2. Maps of manual operational (a) and objective (b) analyses of ocean surface temperature on basis of data for 11-15 June 1980.

Figure 1 schematically represents a region of the North Atlantic subdivided into 10° squares. The upper figure is the number of shipboard communications for a five-day period undergoing preliminary checking and falling into the particular square and the lower figure is the number of communications entering into the "machine map," that is, actually participating in the interpolation. In the tropical latitudes these two figures are usually close, but here, for example, for the square 70-80°N, 20-30°E (the region near the Scandinavian peninsula) the data losses are very great. This is attributable to the fact that an extremely busy shipping lane passes only along the northern shore of the Scandinavian peninsula, whereas the remaining part of the 10° square remains empty. A similar picture is also observed in some other regions.

First of all we require the macroscale temperature fields of the ocean surface. For these purposes the employed search system is entirely satisfactory. But in the northern hemisphere there are a number of places with good coverage and which are of special interest from the point of view of oceanology, such as the Gulf Stream. For these regions it is desirable to carry out "telescoping" of the proposed method, that is, decrease, shall we say, the side of a small square by half in the "machine map" and carry out interpolation in a denser regular grid of points, such as 1 x 1°. The method fully allows all this.

Figure 2, as a comparison, give maps of manual (operational) and objective analyses of water temperature for the North Atlantic for 11-15 June 1980. These maps agree entirely satisfactorily. We note some inevitable smoothing of the results of objective analysis and from our point of view, an inadequate smoothness of the manual analysis fields (taking into account the low measurement accuracy).

I. I. Gromova has kindly carried out a comparison of these two analyses, for which she plotted on a map actually all the water temperature data received during a five-day period and carried out a manual analysis. Then a comparison was made of the results for 250 grid points of intersection covering virtually the entire territory of the North Atlantic. The mean absolute discrepancy was 0.69°C; the

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maximum differences at individual points of intersection attained 3°C (primarily due to an inadequately rigorous checking system).

The USSR Hydrometeorological Center is now receiving a considerable quantity of American data from satellite sounding of the atmosphere in the SATEM code. In addition to other meteorological information the SATEM summaries also contain temperatures of the underlying surface (land or sea). It would be desirable to use these data for supplementing the information for poorly covered regions, primarily for the tropics. However, it was found that the water temperature values present in these satellite summaries very poorly agree with data from shipboard observations; some of them contain blunders.

The computation time when using the scheme is about 10 minutes on a BESM-6 electronic computer. The scheme is now undergoing operational testing.

Other possible ways to improve the quality of objective analysis can be the following:

1. Participation in the analysis of all the information for all available observation times, because this can somewhat improve the results in poorly studied regions.
2. Use of the results of analysis of the preceding five-day period instead of climatic data.
3. Carrying out of investigations of water temperature autocorrelation functions in different regions of the northern hemisphere.
4. Inclusion in the analysis of data from satellite sounding on temperature of the underlying surface (in the case of improvement of their quality).
5. Telescoping of the scheme for individual most interesting regions.
6. Inclusion in the analysis (as reference points) of data from more precise water temperature measurements -- summaries from scientific research ships, buoy observations, and also data from the upper level of abyssal measurements (BATHY, TESAK).

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TSUNAMI OF 23 NOVEMBER 1969 ON KAMCHATKA AND FEATURES OF ITS DEVELOPMENT

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 24 Mar 81) pp 77-83

[Article by Yu. A. Zayakin, Petropavlovsk-Kamchatskaya Hydrometeorological Observatory]

[Abstract] An earthquake with an intensity M = 7.7 and a hypocenter depth 30 km occurred on 23 November 1969 at a distance of 35 km to the east of Cape Ozernoy under the floor of the Bering Sea continental slope. Such an earthquake is a rather rare phenomenon and was the strongest earthquake of this century in the western part of the Bering Sea. A tsunami is also a rare phenomenon in the western part of the Bering Sea. The earthquake and tsunami of 1969 have refuted the idea that this region is free of strong earthquakes and tsunamis and this necessitates amendments to tsunami-earthquake regionalization. Figure 1 is a map representing the focus of the tsunami of 23 November 1969; Figure 2 is a map showing the travel time of tsunami propagation. The tsunami had a complex focal mechanism. The tsunami was formed as a result of changes in bottom relief and due to an underwater slide. The influence of the latter was more important. This is indicated by the southern part of the tsunami focus, lying beyond the limits of the focal region of the earthquake, as well as the good comparability of tsunami wave energy, computed under the condition of formation of the tsunami by a suspension flow, with the energy actually observed. Despite the fact that the strong earthquake of 23 November in the Bering Sea, causing the reported tsunami, was unique in this century, on a preliminary basis a tsunamigenic region must be defined in this zone. It is a continuation of the Kurile-Kamchatkan tsunamigenic zone to the north, along the continental slope, to parallel 58°. The most dangerous sector of the coast, really subject to a threat of a tsunami, is situated opposite the defined zone from the Kamchatkan Peninsula to Ozernyy Peninsula. Figures 2, tables 2; references: 9 Russian.

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RIVER FLOW AS DISSIPATIVE SYSTEM

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 9 Feb 81) pp 84-88

[Article by V. I. Nikora, Odessa Hydrometeorological Institute]

[Abstract] In 1947 M. A. Velikanov outlined three fundamental principles which must be applied in an approach to the study of the channel process. These principles are: interaction between flow and channel, limitedness of natural complexes and minimum of energy dissipation, representing application of the ideas of Rayleigh and Helmholtz to the "flow-channel" system. Although the first two principles have been accepted without special objections, the third has been subjected to acute criticism. Accordingly, the author has reexamined this problem from the point of view of the theory of dissipative structures. With respect to structure, the following assumptions are made in this study: 1. The system is thermodynamically open, that is, there can be an exchange of matter and (or) energy with the medium. 2. The dynamic equations of the pertinent system are nonlinear. 3. Deviations from equilibrium exceed critical values. 4. Microscopic processes occur "cooperatively" (consistently). The "flow-channel" physical system fully corresponds to these assumptions. It is clear that it is thermodynamically open, its dynamic equations are nonlinear, microscopic processes occur cooperatively, it is far from thermodynamic equilibrium and therefore the development of structures in it is possible. Investigation of a river from the point of view of the theory of dissipative structures can be carried out at three scale levels: 1) microscale -- a short river reach in which its hydraulics is interrelated to bottom microforms; 2) mesoscale -- a river reach of considerable extent, whose hydraulics form mesoforms; 3) macroscale -- the river as a whole. Depending on the level at which the "flow-channel" system is investigated, the input external factors must be stipulated (for example, when examining the river as a whole the external factors are climate, geology, geomorphology of the region). At the output is the action of the system -- some channel process. One of the principal concepts describing the behavior of the system in the theory of dissipative structures is entropy, which is a measure of the unordered character of the system. Proceeding on this basis, the author demonstrates that the principle of a minimum of energy dissipation proposed by M. A. Velikanov corresponds to the Prigogine-Glensdorf fundamental principle of a minimum of entropy production applied to fluvial hydraulics. Figures 1; references: 8 Russian.

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SPATIAL CORRELATION FUNCTIONS OF MAXIMUM WATER DISCHARGES IN MOUNTAIN RIVERS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 20 Apr 81) pp 89-93

[Article by M. A. Mamedov, candidate of technical sciences, Azerbaijan State University]

[Abstract] A study was made of the spatial structure of variations of maximum water discharges in mountain rivers of Transcaucasia and Dagestanskaya ASSR. The paired correlation coefficients method was used employing a "Minsk-32" electronic computer in accordance with a program prepared at the State Hydrological Institute. It was found that the mean elevation of the drainage basins in mountain regions exerts a substantial influence on the formation of maximum runoff. The spatial correlation function was represented in the form of the dependence of the paired correlation coefficients on the difference in the mean elevations of the drainage basins. The investigation involved computing the spatial correlation functions for the maximum high-water discharges of rivers on the southern and northeastern slopes of the Greater and Lesser Caucasus and the maximum discharges of flood waters of rivers on the southern slope of the Greater and Lesser Caucasus and elsewhere. The correlation line $r = f(|\Delta H|)$ was constructed with allowance for the computed mean weighted values of the paired correlation coefficients for each elevation gradation, assumed equal to $|\Delta H| = 200$ m. The spatial correlation functions of maximum high-water discharges were computed on the basis of 881 paired correlation coefficient values and for flood waters -- using 215 such values. It was established that in mountainous areas the values of the paired correlation coefficients are dependent not only on the distance between the centers of drainage basins, but also on the difference in the mean elevations of the drainage basins. For mountain rivers the spatial correlation function for maximum discharges can be represented in the form $r = f(\sqrt{\ell \Delta H})$. Figures 3; references: 5 Russian.

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INFLUENCE OF CLIMATIC CONDITIONS ON VARIABILITY OF YIELDS OF GREEN MASS OF PERENNIAL GRASSES IN RSFSR

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 6 Apr 81) pp 94-101

[Article by V. M. Mokiyevskiy, candidate of agricultural sciences, and N. K. Shalyavina, All-Union Scientific Research Institute of Agricultural Meteorology]

[Abstract] The paper gives an analysis of variability of the yields of green mass of perennial grasses in the RSFSR in relation to climatic conditions. Mean oblast data and data averaged for individual economic regions were used for the period from 1961 through 1979, that is, for a period of 19 years. The analysis indicated that the yields of grasses vary considerably from year to year. Table 1 gives statistical data on the yields of green mass of perennial grasses by economic regions and oblasts with information on yield increments over the course of the 19-year period. In all economic regions there was a substantial increase in the yields of grasses during the considered period. The greatest increases were in the European RSFSR in the Volga, Central Chernozem and Northern Caucasus economic regions. In the Asiatic RSFSR the yield increment was considerably lower, especially in the Far Eastern region. High yield increments were observed in the Volgo-Vyatskiy, Central Chernozem, Volga and Northern Caucasus economic regions, attributable not only to an increase in the quantities of mineral fertilizers applied, but also due to an increase in the areas of cultivation of grasses in irrigated lands. Table 2 gives the frequency of recurrence of deviations of yields of green mass of perennial grasses from the trend line as a result of meteorological conditions. Relatively low yield variations occur in the Northwestern and Central regions. Over most of the territory of the RSFSR climatic conditions make it possible to obtain stable yields. Figure 2 is a map of climatic variability of the yields of green mass of perennial grasses in the RSFSR. There is a tendency to an increase in the yield variation coefficient as a result of meteorological conditions from northwest to southeast. This agrees with the general tendency to a decrease in precipitation and an increase in evaporability in this direction. These findings make it possible to predict yields for a long time in advance, assuming an unchanged level of agricultural technology. Figures 2, tables 2; references: 7 Russian.

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INTERANNUAL CHANGES IN ATMOSPHERIC ZONAL CIRCULATION IN NORTHERN HEMISPHERE DURING FIVE-YEAR PERIOD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 21 May 81) pp 102-104

[Article by G. Ye. Vayndiner, T. L. Mukhina, V. P. Gladilina and L. L. Kazakova, USSR Hydrometeorological Scientific Research Center]

[Abstract] Some results of an analysis of year-to-year changes in zonal circulation in the northern hemisphere over the five-year period beginning 1 January 1976 are given. The intensity of zonal circulation is characterized by the index of zonal circulation α/ω (α is the angular velocity of the air relative the earth, ω is the angular velocity of the earth's rotation. (At the present time the zonal index α/ω is widely used in practical work and in developing physicostatistical weather forecasting methods for different times in advance.) In characterizing the year-to-year changes in zonal circulation the authors computed the mean annual and mean monthly values of the indices of zonal circulation at the levels of the isobaric surfaces 700 and 500 mb. Use was made of the daily values of the indices, computed in the process of preparation of experimental hydrodynamic long-range forecasts of deviations of the mean monthly air surface temperatures and absolute topography of the 500-mb surface from the norm for the northern hemisphere, computed on a routine basis on a BESM-6 electronic computer by the section on planetary dynamics of the atmosphere and hydrodynamic long-range weather forecasting at the USSR Hydrometeorological Center. The results are summarized in two tables and two figures. These show that the intensity of zonal circulation in the course of the considered period was subjected to great year-to-year changes. Considerable negative anomalies of the circulation indices appeared early in 1977, 1978, 1980 and 1981. Great positive anomalies of the indices were discovered in early 1976, in the spring and autumn of 1977, and late in 1978 and 1979. Zonal circulation was considerably weakened during 1980. Figures 2, tables 2; references 8: 7 Russian, 1 Western.

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LONG-RANGE FORECASTING OF MAXIMUM WATER LEVELS DURING ICE JAMS ON ANGARA AT KAMENKA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 8 Dec 80) pp 105-107

[Article by V. N. Karnovich, candidate of technical sciences, and T. V. Kuleshova, Scientific Research Institute of Hydraulic Engineering]

[Abstract] Almost every year the breaking-up of the Angara in its lower reach is accompanied by the formation of ice jams. The greatest jams during the last 20 years were observed on 18-26 May 1973 when the water and ice rose more than 12 m above low-water level on the Angara, inflicting great material losses. In order to develop a method for long-range prediction of the maximum water levels during ice jams (H_{jam}) on the Angara the authors analyzed the following long-term series of data from hydrometeorological observations: $\sum t$ -- sum of negative mean daily air temperatures for the period of ice cover; $\sqrt{\sum t}$ -- a parameter indirectly characterizing the thickness of the ice cover; $H_{ice\ form}$ -- maximum water level in initial period of ice cover; T -- duration of setting-in of ice cover. The analysis (using the correlation of H_{jam} with the indicated factors) indicated that not one of the considered factors, taken by itself, with an adequate accuracy determines the maximum water level during ice jams. However, it appears that the decisive factor determining ice jam formation on the Angara is the conditions for setting-in of the ice cover in autumn. A figure shows the dependence $H_{jam} = f(H_{ice\ form})$ for the Angara at Kamenka obtained by the authors using data from long-term series of hydrometeorological data (27 cases of floods); the correlation coefficient for this dependence is r = 0.81. The equation for long-range forecasting of maximum water levels during ice jams on the Angara can be represented in the general form:

$$H_{jam} = f(H_{ice\ form}, T) \tag{1}$$

By means of multiple correlation of H_{jam} with the factors indicated in equation (1) it was possible to derive a numerical prognostic equation for the Angara at Kamenka

$$H_{jam} = 1.53\ H_{ice\ form} + 13.77\ T - 143, \tag{2}$$

A forecast of maximum water levels during ice jams on the Angara at Kamenka can be made not less than 5-5.5 months in advance. The method can be applied for other rivers. Figures 1, tables 1; references: 4 Russian.

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AUTUMN GROWING SEASON OF GRASSY PLANTS IN MODERATELY HIGH ELEVATIONS OF CENTRAL ASIA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 18 Feb 81) pp 107-108

[Article by Yu. S. Lynov, candidate of biological sciences, Chatkal'skiy Mountain-Forest State Preserve]

[Abstract] A study was made of the influence exerted by the conditions of the hydrothermal regime on the course of the autumn growing season at moderately high elevations (1000-2000 m) in Central Asia and the productivity of green mass. Analysis of data for such areas made it possible to derive a regression equation describing the influence of temperature and precipitation sums during the autumn period on productivity. The limits of applicability of the equation are: 50-160 mm of precipitation, temperature sum 300-500°C. A considerable influence on the course of seasonal development of plants is exerted by endogenous factors caused by the biology of the plants themselves, especially during the late summer period and in the reproductive phases of development. During the autumn growing season, during the advent of winter, the development of plants is also held back by endogenous factors. A comparison of indicators of seasonal development during periods identical with respect to hydrothermoregime conditions: autumn (October-November) and spring (mid-February to late March) indicates that spring is more important: in spring the development is more clearly expressed, there are more vegetating species and the productivity of the above-ground part is greater. Although in spring and autumn the length of day differs by 1-1.5 hours, this factor cannot be regarded as important because the length of day exerts a greater influence on the rate of the reproductive phases (flowering, maturing of fruits), whereas in autumn there is a predominance of the growth phases. It is clear that the differences in the indicators of autumn and spring development are attributable for the most part to the influence of endogenous factors during the autumn period. This influence must be taken into account in computations of the autumn productivity of green mass. References: 5 Russian.

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MEASUREMENT OF PARAMETERS OF WAVE-COVERED SURFACE FROM SHIPBOARD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 (manuscript received 28 Oct 80) pp 109-113

[Article by I. P. Trubkin, candidate of physical and mathematical sciences, State Oceanographic Institute]

[Text]

Abstract: The article describes a unit for measuring the slopes and rises of the wave-covered sea surface used by the author in work on the scientific research ship "Akademik Korolev" during the period of the Soviet-American microwave experiment. The author gives the results of an analysis of possible distortions of the spectral components of slopes during drift and rolling of the ship.

Experimental data on wind waves obtained in the open sea are of great scientific and practical interest. Measurement apparatus has been developed for the collection of these data [2, 7, 15]. However, known apparatus is still far from perfect and does not always meet the formulated requirements. In such a case the need arises for developing new measurement apparatus best taking into account the special features of the experiment.

During the period of the Soviet-American microwave experiment (SAMEX-76) specialists aboard the scientific research ship "Akademik Korolev" carried out measurements of the slopes and rises of the wave-covered sea surface. These measurements were made for the purpose of interpreting data on radio emission of the sea surface obtained using microwave apparatus installed aboard the ship. The developed methods and apparatus made it possible to register the rises and slopes of the wave-covered surface in two mutually perpendicular directions relative to the ship. The slopes were measured using wire sensors cut into a finite-difference circuit. The signal characterizing the surface slope in the selected direction was discriminated using a differential measurement circuit. The rises were determined using two sensors (wire and accelerometric) whose signals were subjected to mathematical processing on shipboard using an electronic computer.

The apparatus consists of wire sensors, accelerometer, measurement unit and recorder. The design of the sensors is represented schematically in Fig. 1. It includes four transducers 1, each of which is a high-resistance nonoxidizing wire (Nichrome Ø0.36). The wire is drawn between two rings 2. Attachments in the form of rings

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were used for the purpose of ensuring the minimum influence of waves on rotation of the sensors in the horizontal plane. The sensors were placed in the ship's prow. A weight 3 with a mass of about 20 kg was suspended to the lower ring. The upper ring by means of flexible couplings 4 was fixed in the horizontal plane. The wire sensors were submerged in the water to half their length. The distance between the wires was selected in accordance with [11], taking into account the frequency range of the measured process and the level of instrumental errors. The accelerometer 5 of the tensometric type (measurement range ±1 g) was attached on the ship above the wire sensors.

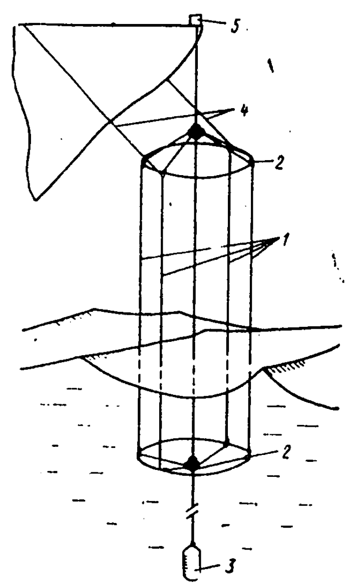

Fig. 1. Diagram of design of wire sensors and their positioning in prow part of ship.

The block diagram of the apparatus (Fig. 2) shows the wire sensors 1 in the form of changeable resistances R1-R4, situated along the axes of Cartesian coordinates XOY. The current source for these sensors is an amplitude-stabilized a-c generator of an acoustic frequency 2. The difference circuits 3-5 serving for the discrimination of the relative change in the level of the input signals constitute differential a-c amplifiers. Circuits 3 and 5 serve for discriminating the differences of the signals of the wire sensors, whereas circuit 4 discriminates the difference between the signals of the sensor R1 and the reference signal U_0 serving for compensation of the constant component of the output voltage of the transducer. The amplitude-phase demodulators 7-9 are for discriminating the envelopes of the output signals of the difference circuits and the d-c amplifiers 10-13 are for amplifying signals from the amplitude-phase demodulators and from the tensometric accelerometer 6. The signals are registered using a multichannel loop oscillograph 14.

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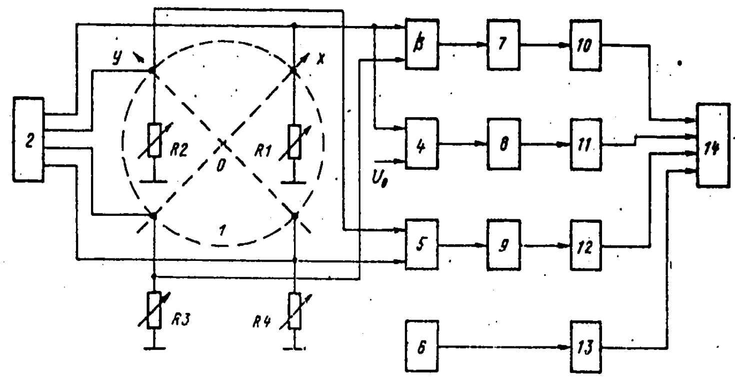

Fig. 2. Block diagram of apparatus for measuring slopes and rises of wave-covered surface from on shipboard.

Principal characteristics of described measurement apparatus:

Range of measured slopes -- $\pm\pi/6$ rad
Range of measurement of relative displacements of sea surface and ship -- ±5 m
Distance between wire sensors -- 0.5 m
Length of sensor wires -- 12 m
Limiting error in measuring each of registered signals -- not more than 5%

The operating principle of the apparatus is essentially as follows. The wire sensors, fed an amplitude-stabilized a-c current, transform the sea level fluctuations into changes in resistivities, linearly determining the amplitudes of the output voltages of the sensors. The difference circuits 3 and 5 discriminate and amplify the voltages of a-c current whose envelopes are proportional to the slopes of the wave-covered surface in the directions of the OX and OY axes. The circuit 4 discriminates a voltage whose envelope is proportional to the relative vertical displacements of the wave-covered surface and ship. The envelopes of the signals of the difference circuits are discriminated by means of amplitude-phase demodulators. The accelerometer transforms the vertical acceleration of ship movement into an electric signal which after amplification, the same as the signals for slopes and relative displacements, is registered on the tape of a multichannel loop oscillograph.

With the use of the described apparatus it is important to take into account the possible distortions of the measured characteristics caused by drift or rolling of the ship. In general form problems of this type were formulated in [4, 13] and solutions were obtained. However, a quantitative evaluation of the possible errors in determining the spectrum of slopes was not made. We will evaluate the mentioned error, assuming that the sensors measuring the slopes move at a constant rate in an arbitrary direction. We will denote the components of the velocity of movement of the sensors, projected onto the axes of the Cartesian coordinate system, by u and v.

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We will seek a solution of the formulated problem within the framework of a linear spectral model of wind waves. Then the slopes of the wave-covered sea surface in the direction of the X-axis, coinciding with the main direction of wave propagation, can be described by the expression

$$\eta_x(t) = \int_{\vec{k}}\int_{\omega} k\cos\theta\, dE(\vec{k},\omega)\exp\times \tag{1}$$

$$\times[i(k\cos\theta\, ut + k\sin\theta\, vt - \omega t)],$$

where $E(\vec{k},\omega)$ is a random stationary process with independent increments related to the energy spectrum of waves $S(\vec{k},\omega)$ by the expression [11]

$$< dE(\vec{k},\omega)\, dE^*(\vec{k},\omega) > = S(\vec{k},\omega)\, d\vec{k}\, d\omega$$

ut, vt are the components of the horizontal spatial vector characterizing the movement of the sensors; $\vec{k} = (k, \theta)$ is the wave vector stipulated in polar coordinates; ω is angular frequency; t is time.

Using the dispersion expression $\omega^2 = gk$ adopted in the linear theory of wind waves, we transform expression (1):

$$\eta_x(t) = \int_{\vec{k}}\int_{\omega} k\cos\theta\, dE(\vec{k},\theta)\exp(i\nu\omega t), \tag{2}$$

where

$$\nu = \left(\frac{k}{g}\right)^{1/2}(u\cos\theta + v\sin\theta) - 1.$$

It follows from (2) that with movement of the sensors the slopes of the waves, measured in the direction of the X-axis, will have a time scale transformed by a factor of ν. This change in scale finds reflection in the frequency region. The spectrum of the transformation process in this case can be represented by the expression [3]

$$\tilde{S}(\omega) = \frac{1}{\nu^2} S\left(\frac{\omega}{\nu}\right).$$

If, using the dispersion expression, we express the two-dimensional spectrum of slopes as a function of only two arguments [8] $S_x(k, \theta) = S(k, \theta)k^2\cos^2\theta$ and take into account the changes in the wave number modulus with a change in the time scale

$$k\left(\frac{\omega}{\nu}\right) = \frac{1}{\nu^2} k(\omega),$$

then it is possible to obtain an expression for the spectrum of slopes of the transformed process

$$\tilde{S}_x(k,\theta) = S\left(\frac{k}{\nu^2},\theta\right)\frac{1}{\nu^8} k^2\cos^2\theta. \tag{3}$$

The two-dimensional wave spectrum is written in the form [6]

$$S(k,\theta) = \frac{2}{\pi}\cos^2\theta\, S(k), \qquad -\frac{\pi}{2} < \theta \leqslant \frac{\pi}{2}.$$

Taking into account that the distortions of the spectral components of slopes during movement of the sensors will be maximum in the high-frequency region, and it is precisely they which in this case are of interest, we will represent the wave number spectrum by its approximation in the equilibrium region [12]:

$$S(k) = Bk^{-4}.$$

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Then, from (3) we obtain

$$\widetilde{S}_x(k, \theta) = \frac{2}{\pi} B v^2 k^{-2} \cos^4 \theta. \quad (4)$$

In integrating (4) for all θ, we find

$$\widetilde{S}_x(k) = Bk^{-2}\left[\frac{3}{4} + \frac{k}{g} \times \left(\frac{5}{8} u^2 + \frac{1}{8} v^2\right)\right].$$

Hence it is easy to obtain the sought-for expression for the relative error in the spectrum of slopes, measured in the general direction of wave propagation:

$$\delta_x = \frac{\widetilde{S}_x(k)}{S_x(k)} - 1 = \frac{2\pi}{\lambda g} \times \times \left(\frac{5}{6} u^2 + \frac{1}{6} v^2\right). \quad (5)$$

Performing similar computations, it is possible to obtain an expression for the relative error in the spectrum of slopes measured in the direction perpendicular to the general direction:

$$\delta_y = \frac{\pi}{\lambda g} (u^2 + v^2). \quad (6)$$

It follows from (5), (6) that with an increase in the velocity of movement of the sensors the errors in determining the spectrum of slopes increase quadratically. The maximum errors will be observed during movement of the sensors along the general direction of wave propagation. If we stipulate the level of the maximum admissible error in determining the spectrum of slopes at 10%, the region of undistorted values will be limited by a curve corresponding to the wavelengths

$$\lambda = 1,06 (5u^2 + v^2).$$

For example, with a velocity of ship drift u = 0.5 m/sec there will be a distortion of the spectral components of the slopes corresponding to wavelengths shorter than 1.3 m, and with u = 1.0 m/sec -- shorter than 5.3 m.

Now we will evaluate the influence of the ship's rolling on the spectrum of measured slopes of the wave-covered sea surface. We will assume that the slopes η_x are measured in the plane perpendicular to the ship's diametral plane. The true slope in the selected direction is denoted by η_1 and the slope of the wire sensors caused by the ship's rolling by η_2. In this case the measured value will be $\eta_x = \eta_1 + \eta_2$. Since the η_x process is determined by the sum of two dependent random processes, its frequency spectrum $S_x(\omega)$ can be expressed by the sum of the auto- and cross-correlation spectra of the terms:

$$S_x(\omega) = S_1(\omega)\left[1 + |\Phi(\omega)|^2 + \Phi(\omega) + \Phi^*(\omega)\right], \quad (7)$$

where $S_1(\omega)$ is the spectrum of slopes; $\Phi(\omega)$ is the transfer function for the ship's rolling.

Then the relative error of the spectrum of slopes will be equal to

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$$\gamma_x = \frac{S_\varepsilon(\omega)}{S_1(\omega)} - 1 = |\Phi(\omega)|^2 + \Phi(\omega) + \Phi^*(\omega). \tag{8}$$

If the transfer function for the ship's rolling is represented in exponential form $\Phi(\omega) = |\Phi(\omega)| \exp[-i\varphi(\omega)]$, then

$$\gamma_x = |\Phi(\omega)|^2 + |\Phi(\omega)|\,[e^{i\varphi(\omega)} - e^{-i\varphi(\omega)}].$$

According to [1],

$$|\Phi(\omega)| = \frac{a\omega_0^2}{[(\omega_0^2 - \omega^2)^2 - 4r^2\omega^2]^{1/2}},$$

$$\varphi(\omega) = \operatorname{arctg}\frac{2r\omega}{\omega_0^2 - \omega^2},$$

where α is a proportionality factor, ω_0 is the characteristic frequency of oscillations of the ship; r is the linear coefficient of resistance to rolling.

As a result we obtain

$$\gamma_x = \frac{a^2\omega_0^4}{(\omega_0^2 - \omega^2)^2 + 4r^2\omega^2} + \frac{2a\omega_0^2}{[(\omega_0^2 - \omega^2)^2 + 4r^2\omega^2]^{1/2}} \times \cos\left(\operatorname{arctg}\frac{2r\omega}{\omega_0^2 - \omega^2}\right). \tag{9}$$

For a quantitative evaluation of the level of errors, for a ship with a displacement of 7000 tons, in accordance with [1] we will assume: $\alpha = 0.5$, $\omega_0 = 0.532$ rad/sec, r = 0.1. Then, if we stipulate the level of errors in the spectrum of measured slopes at 10%, using (9) it is possible to find the limiting frequency ω_{lim} determining the region of undistorted spectral values. For the particular example by use of the iteration method it is possible to find $\omega_{lim} \approx 1.25$ rad/sec.

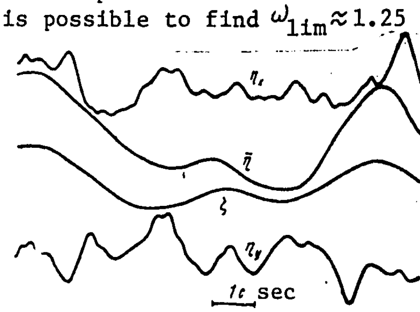

Fig. 3. Sample of records obtained using the described measurement apparatus. η_x, η_y are the wave slopes; $\tilde{\eta}$ is the relative displacement of the sea surface and ship; ζ is the acceleration of the ship's rolling.

The results show that the ship's rolling causes considerable distortions of the spectral components of slopes at frequencies close to the frequency of characteristic oscillations of the ship ω_0. With an increase in frequency relative to ω_0 the level of errors γ_x decreases rapidly. In an ideal case the correction of distortions caused by rolling can be accomplished using the known transfer function

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$\Phi(\omega)$. However, a precise determination of this function is a complex problem. However, if the maximum of the spectrum of slopes corresponds to a frequency greater than ω_0 and ω_{lim}, then, subjecting the measured process to high-frequency filtering with a cutoff frequency ω_{lim} it is possible to obtain records whose spectral characteristics will not be essentially dependent on the ship's rolling.

The error in the spectrum of slopes, measured in the longitudinal direction of the ship, caused by longitudinal pitching, can be evaluated similarly using the transfer function for pitching. In this case in order to exclude the signal components determined by pitching the resulting records of the slopes can also be subjected to high-frequency filtering with a cutoff frequency found from computations.

We note that the ship's rolling also exerts an influence on the vertical component of acceleration, measured using an accelerometer at the point of placement of the wire sensors. It is possible to evaluate this influence, using the known expression [14]

$$W_z = A_x \sin\beta + A_y \frac{\sin\psi}{(1+\mathrm{tg}^2\beta)^{1/2}} + A_z \frac{1}{[(1+\mathrm{tg}^2\psi)(1+\mathrm{tg}^2\beta)]^{1/2}}, \qquad (10)$$

where $A_{x,y,z}$ are the components of acceleration in the coordinate system related to the ship; β is the pitching angle; ψ is the angle of side-to-side rolling.

It follows from (10) that with small rolling angles the sought-for vertical component of ship acceleration W_z will for the most part be determined by the vertical component of acceleration A_z, measured with the accelerometer.

The results of this analysis indicate that using the described apparatus it is possible to measure the slopes and rises of the wave-covered surface from a ship with drift velocities less than 1 m/sec and with rolling angles less than ±10°; then the measurement error does not exceed 10%.

The primary processing of the measurement data obtained using the described apparatus was carried out using a shipboard computer. First the records, represented in the form of curves on the tape of the loop oscillograph (Fig. 3), were transformed into a digital form and punched on a paper tape by means of an analog-digital converter-recorder [5]. In order to determine the displacements of the wave-covered sea surface the accelerations of the ship's rolling were twice integrated with subsequent high-frequency filtering of the series with a Bartlett filter [9] and then subtracted from the values of a number of relative displacements measured by means of a wire sensor.

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REMOTE REGISTRY UNIT FOR FLOAT AUTOMATIC WATER LEVEL RECORDER

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[Article by I. M. Shenderovich, candidate of technical sciences, and L. S. Kleban, Scientific Research Institute of Instrument Making]

[Text]

Abstract: The article describes the design and technical specifications of remote apparatus for observation of water level in rivers, lakes, reservoirs and coastal regions of seas and oceans. The apparatus developed at the Scientific Research Institute of Instrument Making has successfully undergone state acceptance tests and has been included in the USSR Register of Measurement Instruments.

Instrumental observations of the water level in rivers, lakes, reservoirs and in the coastal zone of seas and oceans at most hydrological stations both in the USSR and abroad are made using different types of float automatic recorders. These instruments are reliable in operation, simple to service and their readings are virtually unaffected by change in water density and temperature. However, they also have a number of shortcomings, among which the most important is the lack of remote transmission of data on the measured water level values. This complicates work with the instrument, since it is necessary to wind the clock and remove the tapes on a regular basis. In addition, during a period of critical changes in level, for example, during floods and tsunamis, when there is a need for routine observation of the water level, when the level gage is remote from the building of the hydrometeorological station, it becomes virtually impossible to use it.

A number of ~~authors [1, 2]~~ have repeatedly made attempts to construct float level gages with remote transmission of data, but for a number of reasons they have not been widely employed and have not been industrially produced or introduced in the network of hydrological stations.

Specialists of the Scientific Research of Instrument Making of the USSR State Committee on Hydrometeorology and Environmental Monitoring during 1978-1979 developed a unit by means of which network float automatic water level recorders of the

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SUM, SUV-M and GR-38 type, already in operation in the field, acquire an additional quality -- remote registry of level values measured with the float automatic recorder. This unit, which has been called the 'remote registry unit' (index number AZhN3.009.000), consists of two components: transducer and recorder, shown in the photograph. The transducer in the remote registry unit is mounted directly in the SUV complex, installed over the tide gage well, and serves for transforming the angle of rotation of its float wheel into an electric signal. The recorder, situated in the room of the hydrometeorological station, receives data on the water level and registers it on a standard LGM-2 graph paper. In addition, in this recorder provision is made for the possibility of data output for the purpose of its continuous accumulation on a technical carrier.

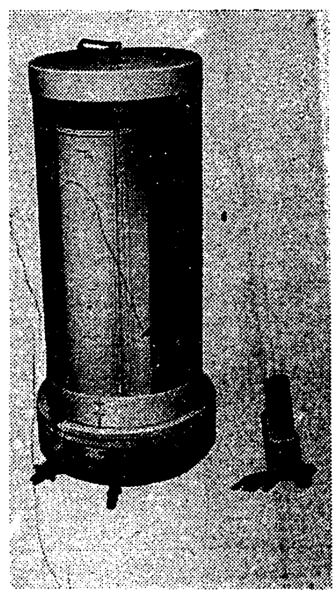

Fig. 1. Remote registry unit for float automatic water level recorder. At left -- recorder, at right -- transducer (for SUM complex).

The operating principle for the remote registry unit [4] is based on a d-c bridge circuit with a balancing system involving use of a reversible electric motor. The arms of the measuring bridge are two precision PPML multiturn potentiometers: one detects the rotation of the float wheel of the SUV complex and is placed in the transducer; the second is for balancing the bridge circuit and is situated in the recorder.

The remote registry unit has the following technical specifications:
-- range of registered water level values -- from 30 to 1200 cm H_2O (depending on the design of the unit);
-- input signal of remote registry unit -- number of revolutions of transducer axis from 2 to 20;

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-- output signal -- movement of arm with pen and mark of recorder -- 300 mm;
-- limit of principal error with respect to input signal -- ±0.5% of measurement range, with respect to output signal -- ±1.5 mm;
-- distance of transmission -- up to 5 km, electric current from sources of d-c current, voltage 12 V;
-- computed probability of faultless operation in course of 10 000 hours -- not less than 0.9.

Three modifications of the unit were developed. These were intended for use in an outfit with float automatic recorders of the SUM, SUV-M ("Valday") and GR-38 types, which differ from one another in the designs of the transducers.

The table gives the indices of design of the remote registry unit in dependence on the range of water level measurement and the type of automatic water level recorder for which they are intended.

Table 1

Design of unit	Type of automatic level recorder	Range of water level measurement, cm
DU-300-I	SUM	300
DU-600-I		600
DU-1200-I		1200
DU-30-II	SUV-M	30
DU-60-II	"Valday"	60
DU-150-		150
DU-300-II		300
DU-300-III	GR-38	300
DU-600-III		600

The transducers for all modifications of the units consist of a reducer with a definite reduction factor, the final link in which is a multiturn precision PPML potentiometer. The input axis of the transducer carries either a pinion or a toothed wheel which is connected to one of the wheels of the transmission mechanism of the corresponding automatic level recorder. In addition, they differ from one another with respect to the point of attachment to the level gages. The reduction factors of the transducers were selected in such a way that regardless of the number of revolutions of their input axis in the working range the potentiometer axis makes 20 revolutions. All three modifications of the ~~transducers~~ with their installation in the corresponding automatic level recorders do not require any additional mechanical changes in their parts and can be placed in already used automatic level recorders without stopping the latter.

With respect to design, the recorder is a cylinder with a diameter of 220 mm and a height of 350 mm. Its main components are a clock mechanism with drum, reducer driven into rotation by a DPM-20 electric motor, electronics unit, zero-setter with control contacts, a vertical guide screw kinematically connected to the reducer and

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serving for movement of a carriage, a supporting arm with pen, mark and permanent magnet along a drum and a vertical scale for visual readout of level values.

The electrical connection of units of the remote registry unit, that is, the transducer and recorder, with one another is accomplished using a three-strand line with a resistance of each strand not greater than 50 ohm.

The circuit diagram of the remote registry unit in an equilibrium state is a balanced bridge consisting of the potentiometers for the transducer and recorder and a zero-setting unit, whose input voltage in this case is equal to 0 when the contacts are open. With a change in water level the automatic water level recorder comes into motion, which results in movement of the potentiometer slide and as a consequence, an unbalancing of the bridge and the appearance of a voltage across the input of the zero-setting unit. At this time the different control contacts close, which determines the direction of water level change. Accordingly, the reversible electric motor is cut in and the direction of rotation of its axis is dependent on the polarity of the imbalance voltage of the circuit. An electric motor, connected through a reducer with the slide of a potentiometer installed in the recorder, moves it up to the moment of circuit balancing. At the same time, the electric motor, also through a reducer, moves along the guide screw a carriage with the pen and mark by a value proportional to the water level change. A second relay in the circuit is used for the output of a signal when the water level attains critical heights -- the maximum and minimum water levels. It is triggered with closing of one of the magnetically controlled contacts mounted on the recorder support and corresponding to the extremal level values.

A calibration device was developed for carrying out laboratory tests and checking the remote registry unit. Developed in three variants, it simulates the angles of rotation of the float wheel of a specific type of automatic wave level recorder [3]. With respect to design it constitutes a mechanical counter of revolutions with two scales. The error in reading the angle of rotation of the transducer axis in the remote unit mounted on the device does not exceed 45 minutes. The calibration device has undergone metrological certification at the Moscow Standardization and Metrology Center.

The remote registry unit for float automatic level recorder has successfully undergone testing and has been included in the State Register of Measurement Instruments which have undergone state tests and which have been certified by the USSR Gosstandart for standard production and use in the USSR.

G. N. Mar, S. A. Folimonov and A. L. Kuskov, specialists at the Scientific Research Institute of Instrument Making, took an active part in developing, adjusting and testing the remote registry unit.

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CONFERENCES, MEETINGS AND SEMINARS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 pp 116-119

[Article by L. V. Rukhovets, L. F. Yermakova, Yu. G. Slatinskiy and N. N. Podgayskiy]

[Text] An All-Union Conference on "Present Status and Problems in Dynamic Meteorology" was held at the Main Geophysical Observatory during the period 22-24 April 1981. The conference was dedicated to the 60th anniversary of the Soviet school of dynamic meteorology. In the early 1920's A. A. Fridman organized a Mathematics Bureau in the Main Physical Observatory and thereby laid the beginning of the Soviet school of dynamic meteorology.

The objective of this conference was not only an evaluation of the successes attained by the Soviet school of dynamic meteorology during a 60-year period, but also the outlining of the prospects for its further development.

The conference sessions were attended by about 150 persons representing 39 organizations of the State Committee on Hydrometeorology and Environmental Monitoring, the USSR Academy of Sciences, Ministry of Education, Academies of Sciences of the union republics and other departments. The participants included specialists from Moscow, Leningrad, Kiev, Minsk, Tashkent, Tbilisi, Alma-Ata, Novosibirsk, Odessa, Kazan', Perm and other cities.

The subject matter of the conference sessions was represented by four sections:

1. History of creation of the Soviet school of dynamic meteorology.
2. Methods for the hydrodynamic prediction of weather.
3. Numerical modeling of general circulation of the atmosphere and climate.
4. Investigations of atmospheric processes by the methods of dynamic meteorology.

In accordance with these sections of the program in the course of the first two days there were conference sessions at which requested reports were presented.

In a report by Academician A. M. Obukhov entitled "A. A. Fridman and N. Ye. Kochin -- Founders of Geophysical Hydrodynamics" there was a timely evaluation of the work of A. A. Fridman and N. Ye. Kochin with the influence of this work on subsequent investigations in the field of dynamic meteorology being considered.

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A report by Academician P. Ya. Polubarinova-Kochina, entitled "Activity of the Mathematics Bureau of the Main Physical Observatory," was devoted to the history of formation of the Soviet school of dynamic meteorology. The report gave interesting details relating to the history of creation of some classical studies of A. A. Fridman, N. Ye. Kochin, L. V. Keller and I. A. Kibel'. The recollections of P. Ya. Polubarinova-Kochina concerning these outstanding scientists, the peculiarities of their human characters and diversions were heard with interest by the conferees.

V. M. Pasetskiy developed his report "On the History of the Dynamic Meteorology Section of the Main Geophysical Observatory" on the basis of an analysis of little-known archival materials. The report described the scientific-historical conditions under which the Soviet school of dynamic meteorology was formed. A number of documents were cited showing how A. A. Fridman validated the idea of creating the Mathematics Bureau.

A report by M. I. Yudin, entitled "Principal Stages in the Development of Dynamic meteorology in the USSR," dealt with problems relating to the history of creation and development of the Soviet school of dynamic meteorology and the present-day problems in this science and also the prospects of its development. The speaker told about the principal achievements of the Soviet school of dynamic meteorology in the 1920's and 1930's and examined the matter of the sequence of investigations. The author pointed out the successive nature of formulation of a number of highly important problems and approaches to their solution. M. I. Yudin noted that the successive nature of the investigations in many respects distinguished the Soviet school of dynamic meteorology and that this is also characteristic of today, although the scope of the problems to be solved has increased by many times and the problems themselves have become much more complex.

The subject matter of the conference, devoted to hydrodynamic weather forecasting, was represented by two reports.

M. A. Petrosyants and V. P. Sadokov, in a report entitled "Hydrodynamic Methods for Short-Range Weather Forecasting," characterized in detail the principal directions in research carried out at the USSR Hydrometeorological Center in the field of short-range weather forecasting. The authors traced the close relationship between the fundamental studies of I. A. Kibel' in this field and further investigations. Emphasis was on investigations in the field of mesometeorology directed to the development of local (mesometeorological) weather forecasts. These investigations, to which I. A. Kibel' also made a major contribution, have now been brought to the stage of formulation of a model having prognostic importance.

A report by S. A. Mashkovich, entitled "Use of the Methods of Dynamic Meteorology in Middle-Range Forecasting," was devoted to an exposition of hydrodynamic methods for the forecasting of meteorological elements for intermediate-length periods; these are based on use of the spectral approach. Investigations in this direction, initiated by a study of Ye. N. Blinova in 1943, are now being developed intensively at the USSR Hydrometeorological Center, at the Main Geophysical Observatory and at other institutes.

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Three reports were devoted to the problem of numerical modeling of general circulation of the atmosphere and climate.

A report by Academician G. I. Marchuk and V. P. Dymnikov, entitled "Modeling of Climate and Its Changes," gave a formulation of the general principles lying at the basis of solution of the problem of hydrodynamic modeling of climate and its changes, caused by different factors. The application of these principles was illustrated in the examples of models of climate developed at the Computation Center of the Siberian Department of the USSR Academy of Sciences.

The report of G. P. Kurbatkin, corresponding member, USSR Academy of Sciences, entitled "Influence of the Ocean on the Dynamics of Climate," contained a new approach to solution of problems in the theory of climate, making it possible to evaluate the influence of nonadiabatic factors of different spatial scale on the mechanisms of climatic change. In particular, this approach will make it possible to evaluate the contribution of processes transpiring in the ocean on the dynamics of climate.

Ye. P. Borisenkov and V. P. Meleshko, in a report entitled "Investigation of General Circulation of the Atmosphere," presented the results of work on study of the patterns of general circulation of the atmosphere using a number of models of different complexity developed at the Main Geophysical Observatory. Using these models it was possible not only to study the patterns of the existing regime of general circulation of the atmosphere, but also to evaluate its possible changes as a result of anomalous sources of anthropogenic and nonanthropogenic origin. Using one of the developed models, a study was also made of some features of the circulation regime of Mars.

A. M. Yaglom, in a report entitled "Fridman-Keller Equations for the Moments of Turbulent Pulsations and the Problem of Their Closure," gave a detailed analysis of investigations devoted to one of the most important problems in the theory of turbulence -- the so-called "closure problem."

A report by L. T. Matveyev discussed the principal problems of cloud dynamics. In order to clarify the peculiarities of formation and structure of macroscale cloud cover fields a numerical solution was obtained for a system of equations in hydrothermodynamics for a turbulent atmosphere. Some characteristics of the global cloud cover field are considered, in particular, the dependence of the the distribution for the quantity of clouds on the averaging area.

The last day of the conference sessions was devoted to "stand" reports in which a number of problems in dynamic meteorology were considered.

The following studies were presented:

1. V. A. Shnaydman (Odessa Hydrometeorological Institute). "Theoretical and Practical Aspects of Boundary Layer Physics."

2. V. M. Kadyshnikov (USSR Hydrometeorological Center). "Role of Turbulence in the Setting-In of a Geostrophic Balance of Macroscale Atmospheric Movements."

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3. L. V. Berkovich (USSR Hydrometeorological Center). "Nonadiabatic Hemispherical Model of the Atmosphere for Prediction for Several Days in Advance."

4. Yu. P. Perevedentsev, M. A. Vereshchagin, V. V. Gur'yanov and K. M. Shantalinskiy (Kazan' University). "Some Results of Investigation of Meridional Transports of Matter and Energy in the Free Atmosphere."

5. V. V. Khvedelidze (Tbilisi University). "Wave Propagation in Atmosphere With Allowance for the Simultaneous Influence of Orography and the Beta Effect."

6. V. I. Martem'yanov (Central Asian Scientific Research Institute) "Choice of Reckoning Levels Vertically in Forecasting Schemes in Dependence on Horizontal Resolution."

7. V. V. Shpotov (Central Asian Scientific Research Institute). "Formulation and Analysis of Computation Properties of Semi-Implicit Schemes for Integration With the Second and First Orders of Accuracy."

A resolution adopted by the conference notes the considerable successes attained by the Soviet school of dynamic meteorology, in many respects standing at the forefront of modern meteorological science.

The conference recommended the development of research in the following fundamental directions:

-- improvement in numerical methods for short-, intermediate- and long-range weather forecasting;
-- development of a hydrodynamic theory of climate and general circulation of the atmosphere;
-- formulation of a theory of atmospheric turbulence;
-- study of mesometeorological phenomena and local processes;
-- improvement in methods for parameterization of the most important physical processes in the atmosphere;
-- investigation of interaction between the ocean and atmosphere.

It was decided to hold an All-Union Conference on Dynamic Meteorology and Its Principal Practical Applications during the current five-year plan and also to hold special working conferences regularly on the use of the methods of dynamic meteorology in numerical models of climate and weather forecasting, especially with respect to the parameterization of hydrological processes and the atmospheric boundary layer, cloud formation processes, etc.

The conference also noted the immediate need for preparing a new textbook on dynamic meteorology for colleges in which there would be a systematic exposition of the modern aspects of this science and in which proper attention would be given to the historical development of the ideas and methods used in dynamic meteorology.

It was decided that a collection of papers from the conference be prepared for publication.

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An extensive exhibit of literature from the library of the Main Geophysical Observatory was opened during the course of the conference and there was a stand displaying documents on the history of creation of the Mathematics Bureau and photographs of its first specialists.

L. V. Rukhovets

A conference-seminar on methods for determining contaminating substances in sea bottom deposits was held during the period 23-28 March at the Sevastopol' Division of the State Oceanographic Institute. The conference-seminar was attended by representatives of the State Oceanographic Institute, Azerbaijan, Amderma, Georgian, Kazakh, Murmansk, Northern and Ukrainian Administrations of Hydrometeorology and Environmental Monitoring. The conferees examined the peculiarities involved in determining petroleum products, chlorinated hydrocarbons and heavy metals in bottom deposits. As a convenience in work the seminar participants were divided into four groups, each of which was successively familiarized with all the analyses.

During the years of the Tenth Five-Year Plan the subdivisions of the State Committee on Hydrometeorology and Environmental Monitoring have done much work for creating a unified national service for observing and monitoring the state of the environment. A network of hydrochemical laboratories has been established in the marine administrations of hydrometeorology and environmental monitoring. Under the methodological direction of the State Oceanographic Institute they annually carry out a great volume of observations. In the Black Sea basin alone subdivisions of the Ukrainian, Northern Caucasus and Georgian Administrations of Hydrometeorology and Environmental Monitoring during 1976-1980 made more than 350,000 hydrochemical observations, including about 100,000 in the mouth regions of the Danube, Dnepr, Don, Kuban and Rioni. At the same time, investigations of bottom deposits for the time being have not been fully developed in the marine network.

The participants in the conference-seminar noted that in connection with the increased attention to the problem of preservation of the sea medium from contamination the study of the surface layer of bottom deposits both within the continental shelf and in the abyssal zone of the seas is now becoming one of the timely problems at network hydrochemical laboratories. Accumulating a considerable part of the contaminating substances entering the sea, the bottom deposits are an integral indicator of the degree of their contamination. On the basis of the results of an analysis of the bottom deposits, which in contrast to a water mass are a more static and conservative zone, it is possible to evaluate the degree of the anthropogenic influence on the hydrometeorological regime in different regions of the sea.

It is also noted that contaminated bottom deposits, especially in the shallow-water regions of the shelf, in the case of heavy waves can favor a secondary contamination of sea waters. The level of accumulation of chemical substances in the bottom deposits is determined by the total effect of a great many factors, but all other conditions being equal, the intensity of accumulation is highly dependent on the mineralogical and granulometric composition of the bottom material, that is, increases with transition from sandy to clayey ground and from coarsely disperse to finely disperse (pelitic) fractions.

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In characterizing the introduced unified methods for determining contaminating substances in bottom deposits it was noted, in particular, that in the process of accumulation of heavy metals in the bottom material an active role is played by natural sorbents -- complex formers, as a result of which the nature of distribution of many metals in the bottom material is closely associated with the content of natural organic substances in them. Such a consistency was established for most of the elements, a determination of which is provided for by the used methods. The mechanism of this consistency is related to the peculiarities of the molecular structure of some organic compounds, which in this case play the role of complex formers and sorbents in the water-bottom material system. For example, the migration of mercury (especially in organic form) occurs with the active participation of the biomass in the surface layer of bottom deposits. For chemical compounds of other metals (copper, lead, cadmium, etc.) there was found to be a dependence of migration on natural sorbents of mineral origin.

In discussing the material-technical support of work for introduction of unified methods for determining contaminating substances in sea bottom deposits the participants in the conference-seminar emphasized that in this problem there is need for more active assistance on the part of the State Committee on Hydrometeorology and Environmental Monitoring and local administrations of the Hydrometeorological Service. In particular, it was noted that it is necessary to accelerate the output of new modifications of samplers (corers, dredges, etc.) and in the hydrochemical laboratories of the key hydrometeorological observatories in all basins organize a system for the internal and external monitoring of adherence to methods for carrying out the most complex and responsible work. It was noted that each year it is desirable to carry out training of specialists in the sea network in the field of gas-fluid chromatography and atomic absorption spectrophotometry.

In the adopted resolution the participants in the conference-seminar formulated a number of priority tasks for the further development of hydrochemical investigations and monitoring of the state of bottom deposits in basins.

L. F. Yermakova and Yu. G. Slatinskiy

A coordination conference on improvement in the hydrological study of the territory of Sverdlovskaya Oblast was held in Sverdlovsk on 17 February. It was organized on the initiative of the Ural Administration of Hydrometeorology and Environmental Monitoring. It was attended by representatives of a number of scientific research and planning institutes, production-technical enterprises, the oblast sanitary-epidemiological station and other organizations.

The conferees heard reports on the prospects for rationalization and further development of the network of hydrological stations over the territory of the oblast, on measures for improving reciprocal hydrological information, on coordination of interdepartmental efforts in improving hydrological study of the territory of the oblast and organization of hydrological reserves in the Urals.

An adequately high level of hydrological study of the Ural region was noted. On all the major and intermediate rivers hydrological engineering investigations were made. The exploitation of water resources is also expanding. In the oblast there are no longer any rivers which are not used by national economic organizations.

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Numerous hydraulic structures regulating runoff, the discharge of industrial effluent, and the great number of water supply boreholes substantially changed the natural regime of the water features. The hydrological characteristics and parameters obtained earlier no longer reflect the present-day water regime. An acute need has arisen for study of the impaired regime of rivers and lakes and also for solution of the problem of creating hydrological reserves.

The conferees emphasized that the success of the expanded and deepened hydrological study of the territory under conditions of a disrupted regime for solution of the national tasks of inventorying of waters and conducting the USSR Water Survey to a considerable degree will be dependent on the coordination of efforts of the administrations of the Hydrometeorological Service and all interested organizations and departments.

The conference assigned to the Sverdlovsk Hydrometeorological Observatory the task of preparing a plan of measures for coordination of interdepartmental efforts for improving the hydrological study of the territory of Sverdlovskaya Oblast in 1981-1985.

It was deemed necessary to strengthen checking of the volumes of water intake and discharge of industrial runoff and improve the determination of water discharge from dams and other structures.

The conference recommended that major water users organize year-round runoff posts with the methodological assistance of the Ural Administration of Hydrometeorology and Environmental Monitoring.

It was proposed that interested organizations annually send to the Sverdlovsk Hydrometeorological Observatory their proposals on development of the hydrological network.

It was pointed out to departmental organizations that it is inadmissible to send requests and programs to the Hydrometeorological Archives at a late date for obtaining permission for the carrying out of hydrological work or delaying the sending of data on the work done by them.

A resolution was adopted calling for the petitioning of the Sverdlovsk Oblast Executive Committee for the creation of hydrological reserves at the headwaters of a number of regions in the oblast.

The opinion was expressed that it is desirable to hold coordination conferences on hydrological study of the territory not less than once every other year.

N. N. Podgayskiy

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NOTES FROM ABROAD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 pp 119-120

[Article by B. I. Silkin]

[Abstract] During the last thousand years some of the phases of activation of volcanic activity on the earth have coincided in time with macroscale climatic changes. However, an analysis of cause-and-effect relationships in the presence of two fluctuating systems is usually difficult. Such an attempt, limited to the time interval between 1870 and 1970, has now been made by Doctor S. Porter at the University of Washington. The periods of advance of glaciers in the northern hemisphere were 1880-1895, 1910-1925 and the time from the mid-1950's through the present time. In the southern hemisphere they do not coincide with the northern hemisphere: there the advance of glaciers occurred in the mid-1870's and during the period from 1906 through 1910, the first half of the 1930's and the late 1940's. Studying ice cores obtained by drilling in both hemispheres, S. Porter, in addition to absence of synchronism in the glaciation cycles, discovered that in each case the period of advance of glaciers coincides with a time interval during which the deposition of acid-bearing substances ejected in the course of volcanic eruptions increases. This is easily traced in the glaciers of both Greenland and Antarctica. Thus, at least during the last century it is possible to speak of the presence of a cause-and-effect relationship between volcanic activity and glaciations operative independently in the two hemispheres.

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An environmental contamination bank has been established at Aachen, in West Germany. Until now measures for contending with contamination in West Germany have frequently been impeded by the lack of a clear picture of the preceding state of the medium. In West Germany there are ten groups, established since 1979, for collecting data in this field. The new data bank was organized at the Institute of Atomic Energy Research. It will coordinate all work along these lines. In the first stage the bank will concentrate its attention in the field of data relating to man himself, his food chain and habitat. This includes the collection of samples of human blood, liver, fatty tissue and certain food products such as fish, mollusks, wheat and milk. Other samples include algae, soils, grass, earthworms and various insects. Their content of hydrocarbons, pesticides and toxic metals will be analyzed. Each sample will be analyzed immediately upon receipt and then at equal time intervals. The storage of samples is in dust-impermeable rooms at temperatures in some cases attaining -190°C. These rooms have an emergency cooling system.

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In April 1981 American scientists began carrying out the four-year program CODE (Coastal Ocean Dynamics Experiment), the objective being study of the dynamics of coastal waters in the Pacific Ocean washing the northwestern shores of California.

In the course of these studies they are collecting diversified information on the processes exerting an influence on the development of currents, on wind fields, physics of the upper layers of the ocean and its coastal part, sea level, pressure at the bottom in the shelf zone, seasonal circulation and other parameters. Over a distance of 97 km along the coast anchored velocity meters are being set out, together with instrumentation for measuring current direction. Participating in the experiment are scientific research ships of the University of Oregon and the Scripps Oceanographic Institute, as well as the national laboratory at Boulder. Other participants will include the Geological Survey, NASA and NOAA.

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ANNIVERSARY OF BIRTH OF YU. M. SHOKAL'SKIY (1856-1940)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 12, Dec 81 pp 120-121

[Article by V. M. Chuvashov]

[Abstract] This year marks the 125th anniversary of the birth of Yuliy Mikhaylovich Shokal'skiy, outstanding Russian and Soviet oceanographer, meteorologist and cartographer. After studying at the Marine Institute, he spent two years in the Navy, after which he became a student at the Marine Academy in the hydrography division. During 1880-1882 he headed the marine meteorology section of the Main Physical Observatory. Between 1882 and 1907 he taught at the Marine Institute and then through 1930 at the Marine Academy. From 1925 to his death he was also a professor at Leningrad University. Meanwhile, during 1907-1912 he headed the meteorology section of the Hydrographic Administration and from 1925 through 1931 he was director of the State Cartographic Institute. On his initiative and with his direct participation various measures were undertaken for investigating the regime of water basins. He was responsible for numerous aerological and ice observations. He organized oceanographic expeditions for studying the Black Sea. He made large-scale observations of currents in the Baltic, Black, Caspian and Far Eastern seas. He organized publication of the first YEARBOOKS OF TIDES and established the Sevastopol' Marine Observatory. Yu. M. Shokal'skiy was one of the supporters and founders of study and exploitation of the Northern Sea Route. As early as 1883 he was an advocate of study of the Arctic and Antarctica. A major result of his investigations was the generalizing work OKEANOGRAFIYA (Oceanography)(1917). In this monograph the scientist for the first time pointed out the interrelationship of processes and phenomena transpiring in ocean and sea waters and also in the world ocean and atmosphere. The scientist published about 1,500 scientific works -- monographs, articles, atlases and reference books with an astonishing breadth in virtually all fields of geography. Shokal'skiy was an outstanding cartographer and headed work on compilation of maps of the relief of Russia. He calculated the area of the Asiatic part of Russia and the lengths of major rivers. He played a major role in the preparation of innumerable atlases. He participated in preparations for the Second International Polar Year and represented the USSR at many international geophysical congresses. Yuliy Mikhaylovich devoted 58 years of his scientific activity to work in the Geographical Society. Between 1917 and 1931 he was chairman and thereafter was honorary chairman. He was a doctor of geographical sciences, a doctor of physical and mathematical sciences, a corresponding member of the USSR Academy of Sciences and an honorary member of countless societies in the USSR and abroad. His contributions to the development of Russian and Soviet geography were enormous. References: 5 Russian.

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